APPARATUS FOR THE DISTRIBUTION OF WATER FROM AUTOMATIC SPRINKLER HEADS

BY

W. H. RIETZ

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ARMOUR INSTITUTE OF TECHNOLOGY

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THE DESIGN AND APPLICATION OF APPARATUS FOR DETERMINING THE DISTRIBUTION OF WATER FROM AUTOMATIC SPRINKLER HEADS

A THESIS

presented by

Walter H. Rietz and Theo. K. Pfafflin

to the

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN

FIRE PROTECTION ENGINEERING

having completed the prescribed course

of study in

FIRE PROTECTION ENGINEERING.

1915

H M Raymond
L. C. Monin

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The writers take this opportunity to express their appreciation of these favors.

PREFACE

The importance of the subject for investigation lies in the fact that, if a sprinkler head is to operate as a result of a fire, it should discharge the water in sufficient quantity, break up the water into the correct form, which is that of heavy drops, and distribute the water properly over the floor, ceiling, and sides.

Previous to this time only one investigation had been carried out at the Underwriters' Laboratories. The apparatus for this investigation consisted of a series of one hundred and forty-four pans, each one foot square at the top and one foot deep, a device for exposing the pans to the water from the sprinkler head so that each pan was exposed the same length of time, and a device for measuring the quantity of water in each pan. The results obtained were not what were expected and the method and time required for measuring the quantity of water in each pan was impractical. The only conclusion drawn from this investigation was that the distribution of water from a sprinkler head in an upright position was much better than that in a pendant position. Up to this time, the question of distribution of water from sprinkler heads has been left to the judgment of a competent engineer without the use of apparatus.

The need of a standard method and design of a system by which the distribution of the water can be quickly and accurately determined is evident. The design, construction, and application of such a method and system is the prime object of this investigation.

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PART ONE

THE DESIGN OF THE APPARATUS

CHAPTER I.

INTRODUCTION

The apparatus devised for determining the distribution consists of pans for collecting the water thrown from the head; a carriage for supporting the pans and a cover for shielding them before and after the run; a plane ceiling for determining the ceiling distribution, with rings hung from it for estimating the side distribution; an adjustable water supply for tests at various pressures; and a discharge hood and tank for determining discharge curves of the various heads.

In the design of the pans, the major intention was to provide a set of pans divided in a way which would tell the most about the distribution of the water from the sprinkler head. Minor intentions were to make the pans of a material strong enough to hold the contained water without warping out of shape at the place where they were lifted; to make the division of a size, which, after the above question of distribution had been considered, would permit ease of handling by two men; to provide laps on the pans so that no water would be allowed to go to waste between them; and to provide handles on the pans at places where they would not interfere with the fitting together of the pans.

In the design of the carriage, the intention was to provide a frame so that the pans would be well supported in a level position and so that the entire set of pans could be swung around into any sector of the circle into which the head was to throw water. A pivot was also designed which acted as the center of revolution and as a leveling device for the pans and carriage.

The cover was designed with the intention of providing a means of shielding the pans from the water until the pressure was adjusted, at which time it could

be swung from over the pans and around the complete circle so that when the time came for again shielding the pans from the water, the cover could be swung on in the same direction as that in which it was taken off so that each pan would be exposed the same length of time. It was necessary to provide means of drainage and to provide stops so that no water from the cover would be spilled into the pans while the cover was in motion.

CHAPTER II.

THE DESIGN OF THE PANS

The failure of the square pan method for giving the expected results led to the idea that distribution could best be studied by determining the quantities of water which fell in zones of a circle on the floor, the center of which was directly under the head. It is clear that it would be unnecessary to make pans enough to fill the whole circle, since a sector of pans could be easily set in any sector of the circle.

After considering the number of settings to make a complete circumferencial test and the accuracy with which the distribution should be determined, it was decided that a sector with an angle of forty-five degrees (45°) should be covered by the pans. It would, therefore, require eight settings to make a complete test.

The next thing to be considered was the radial divisions of the pans. The area which a sprinkler must cover is that of a ten foot square or one hundred square feet. The diagonal of this square is fourteen and fourteen hundredths feet (14.14'), so that, in order to study the distribution in any part of the square, it would be necessary to make the radius of the circle of which the pans are a sector, seven and seven hundredths feet (7.07'). In order to adequately cover this area, they were made seven and five tenths feet (7.5'). Starting from the center, radial divisions were made at the two, three, four, five, and six foot marks. This made a total of six zones. These divisions were based entirely on Mr. Alling's experience from the previous investigation. For the purpose of greater accuracy, the pans in the third, fourth, and fifth zones were divided so that each pan subtended an angle of twenty-two degrees and thirty minutes (22°-30') at the center of the circle. The pan in zone six was divided so that each division subtended an angle of eleven degrees and fifteen minutes (11°-15') at the center.

TABLE OF AREAS, VOLUMES, AND WEIGHTS OF WATER IN THE PANS.

ZONE NO.	NO. OF PANS IN ZONE.	AREA FT.^{2}	VOL. GALS.	WT. LBS.
1	1	1.57	11.74	98.1
2	1	1.97	14.73	123.1
3	2	1.37	10.23	85.6
4	2	1.77	13.21	110.4
5	2	2.16	16.15	134.8
6	4	1.99	14.91	124.6

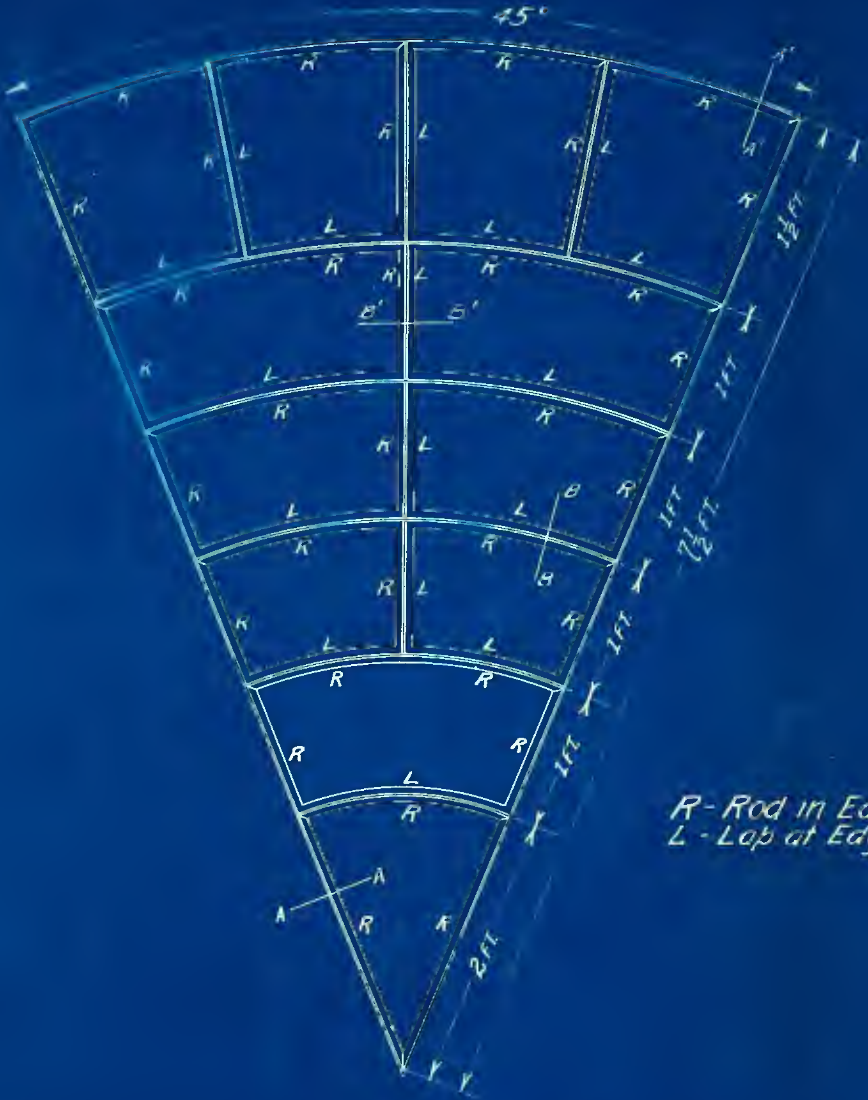
The next problem was that of deciding upon the material of which the pans were to be made. After examining several gauges of metal, it was decided that U. S. gauge number twenty (20), galvanized iron would be strong enough and would not rust. The pans were specified to be soldered and riveted throughout.

Together with the question of division for greater accuracy mentioned above the ease of handling by two men was considered. This was based upon the approximate quantity of water which two men could lift.

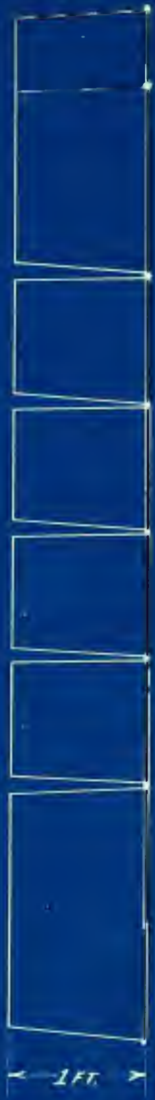
Laps were provided on the pans so that they would not only fit together well and be easy to set up, but so that no water would be allowed to go to waste in between the pans.

Handles were provided so that the pans could be easily lifted on to scales for determining the quantity of water in them. The handles were placed on the inside of the pans three inches (3") below the top edge, in order not to interfere with the fitting together of the pans, and to prevent water from splashing from the handles into adjoining pans.

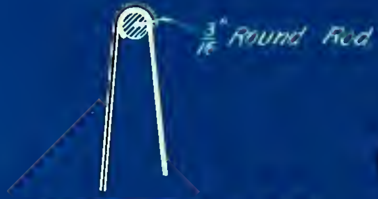
ASSEMBLY OF PANS.
SCALE - 1" = 1 FT.
MAY 1915.
W.H.R. T.K.F.



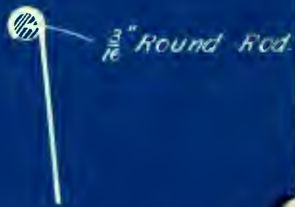
R - Rod in Edge.
L - Lap at Edge.



Made of No. 20 Gage galvanized iron.
Scale - 1" = 1 FT.



Section B-B or B'-B'.



Section A-A or A'-A'.

CHAPTER III

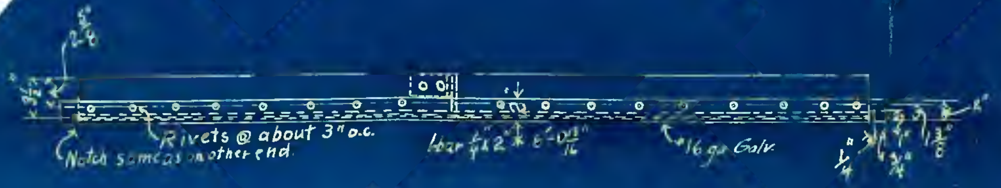
THE DESIGN OF THE CARRIAGE

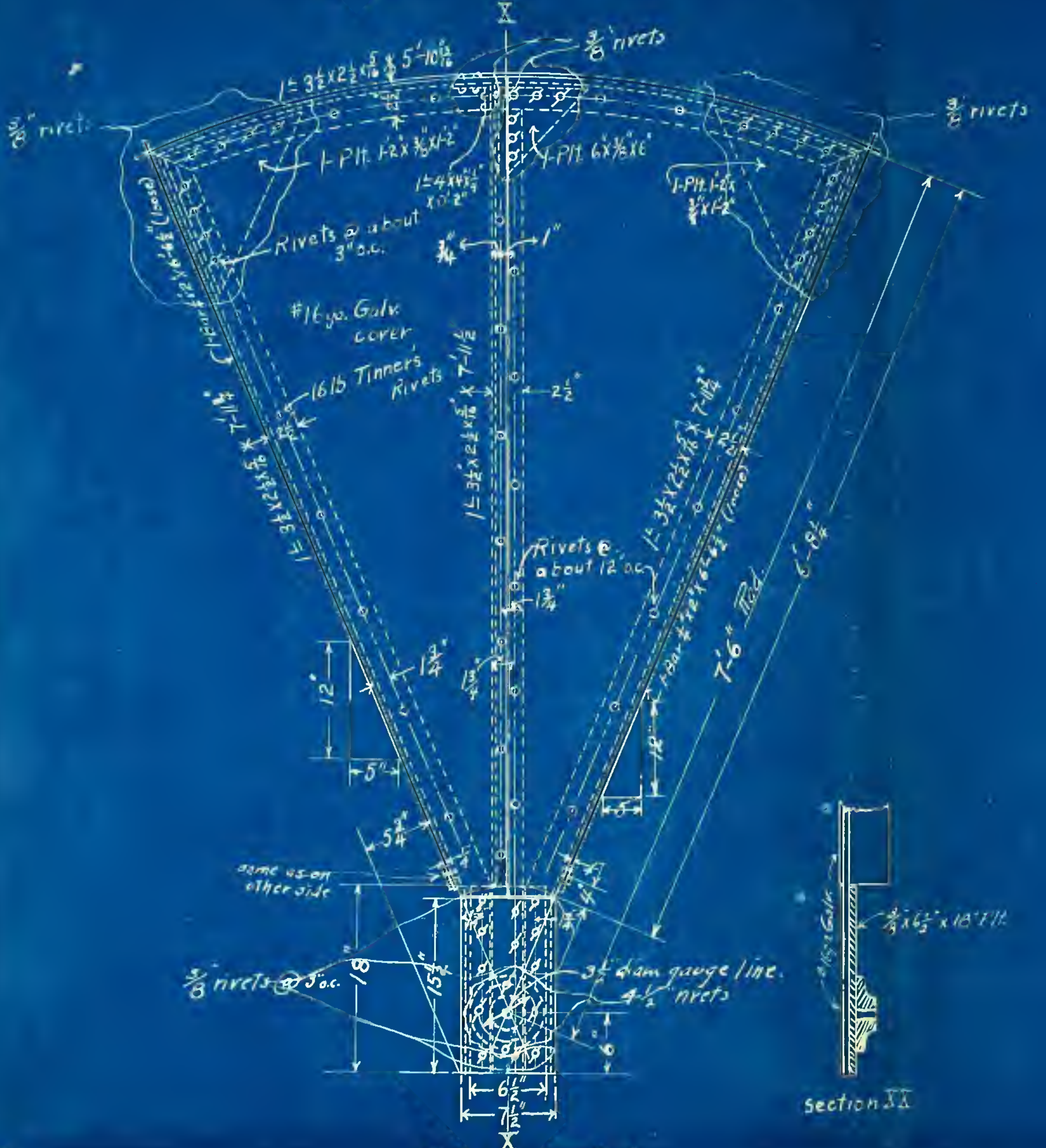
Because of the fact that the pans covered only a fraction of the total area sprinkled by the head, it was thought convenient and necessary to provide a carriage upon which the pans could be supported in a level position, and which would afford a means of moving the entire set.

The shape of the carriage was that of the series of pans, being slightly larger all around and allowing for a space near the center where a pivot for the cover could be attached. The carriage was designed strong enough to hold all the pans full of water with a large factor of safety.

The carriage was made up of four angles, three of which were bent to conform with the shape of the pans and a fourth added so that both sides of the pans were supported. The angle iron framework was assembled by means of gusset plates. A socket for a pivot consisting of a flange was mounted on the under side of the frame directly at the center of the circle. In order to hold the pans in their respective positions, strips were placed on the sides, two of which were removable to afford greater ease in removing the pans. Three castors were bolted on the under side of the frame so that it could easily be moved over the floor. When the center was supported by the pivot, the two castors on the circumference were touching the floor so that the carriage could be swung around the circle. The top was covered with U. S. gauge number 16 galvanized iron. The rivet heads were flattened so that a smooth surface was at hand on which to support the pans.

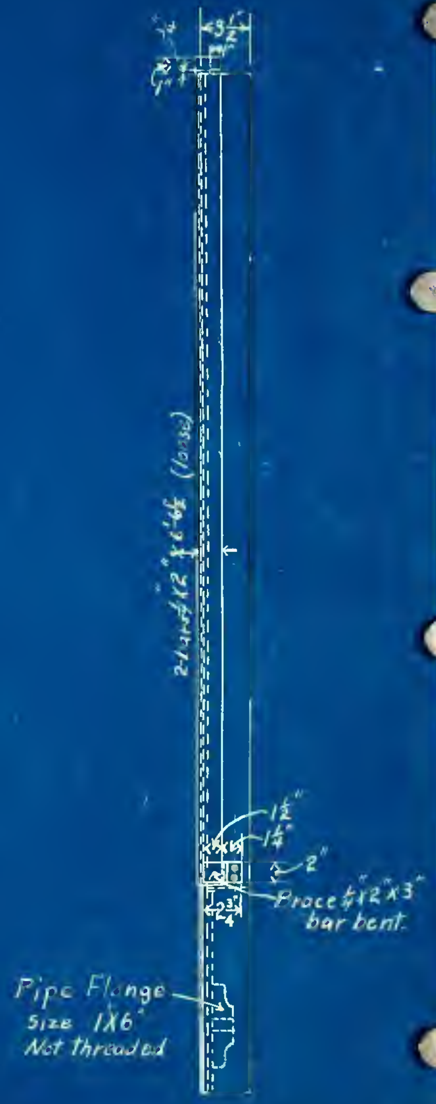
A pivot for the carriage was made of a pipe flange and fittings. A levelling device was contained in the pivot, and consisted of a long thread nipple.




X
$\frac{3}{8}$" rivets
1∠ 3$\frac{1}{2}$x2$\frac{1}{2}$x$\frac{5}{16}$ x 5'-10$\frac{13}{16}$
$\frac{3}{8}$" rivets
$\frac{3}{8}$" rivets
1-Plt. 1-2x$\frac{3}{16}$x1-2"
1-Plt. 6x$\frac{3}{16}$x6"
1∠ 4x4x$\frac{1}{4}$ x 0'-2"
1-Plt. 1-2x$\frac{3}{16}$x1-2"
Rivets @ about 3" o.c.
$\frac{3}{4}$"
1"
1 bar $\frac{1}{4}$x2 x 6'-6$\frac{3}{8}$" (loose)
#16 ga. Galv. cover
16 lb Tinners Rivets
2$\frac{1}{2}$"
1∠ 3$\frac{1}{2}$x2$\frac{1}{2}$x$\frac{5}{16}$ x 7'-11$\frac{1}{4}$
1∠ 3$\frac{1}{2}$x2$\frac{1}{2}$x$\frac{5}{16}$ x 7'-11$\frac{1}{2}$
1∠ 3$\frac{1}{2}$x2$\frac{1}{2}$x$\frac{5}{16}$ x 7'-11$\frac{1}{4}$
1 bar $\frac{1}{4}$x2 x 6'-6$\frac{3}{8}$ (loose)
7'-6" Rad.
6'-8$\frac{1}{4}$"
Rivets @ about 12" o.c.
1$\frac{3}{4}$"
1$\frac{3}{4}$"
1$\frac{3}{4}$"
12"
12"
5"
5"
5$\frac{3}{4}$"
same as on other side
$\frac{3}{8}$ rivets @ 3" o.c.
18
15$\frac{1}{4}$"
3$\frac{1}{2}$" diam gauge line.
4-$\frac{1}{2}$" rivets
6
6$\frac{1}{2}$"
7$\frac{1}{2}$"
X
#16 ga. Galv.
$\frac{3}{8}$x6$\frac{1}{2}$"x18" Plt.
Section XX

FRAME A1

1-Required


3$\frac{1}{2}$"
2-1 bar $\frac{1}{4}$"x2" x 6'-6$\frac{3}{8}$" (loose)
1$\frac{1}{2}$"
1$\frac{1}{4}$"
2"
2$\frac{3}{4}$"
Brace $\frac{1}{4}$"x2"x3" bar bent.
Pipe Flange Size 1X6" Not Threaded

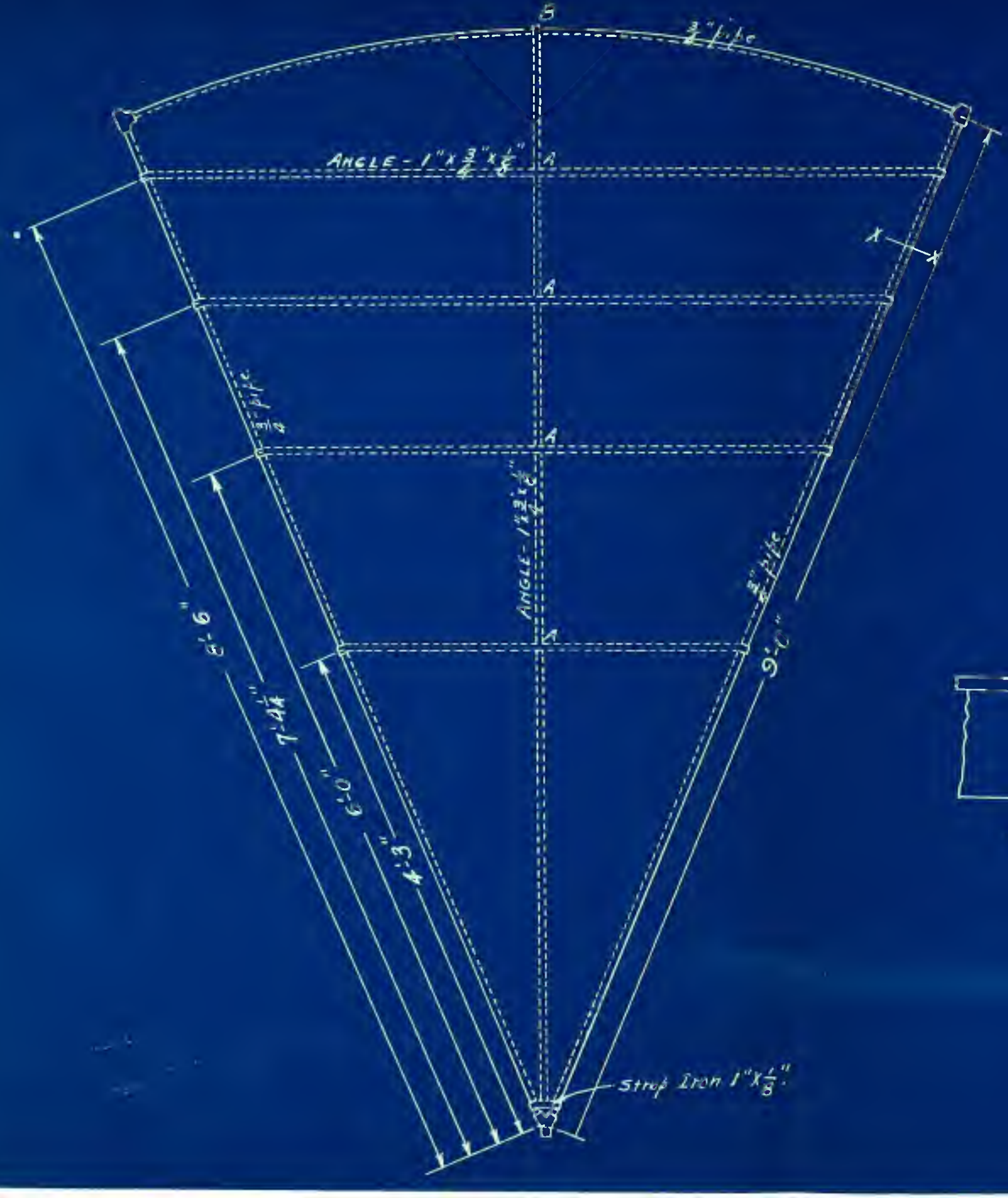
ASSEMBLY OF THE CARRIAGE FOR PANS.

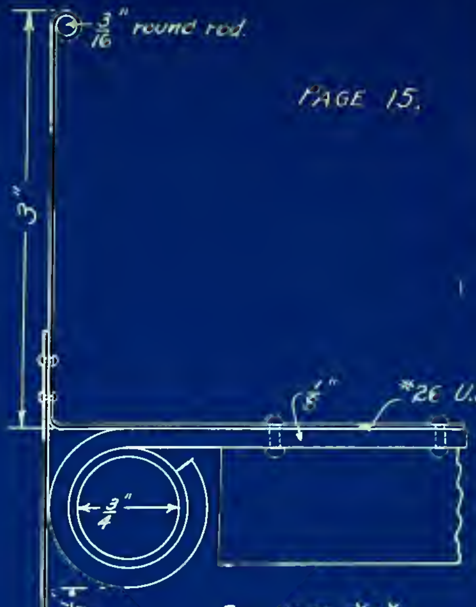
by W.H. Rietz.
T.K. Pfofflin.

CHAPTER IV.

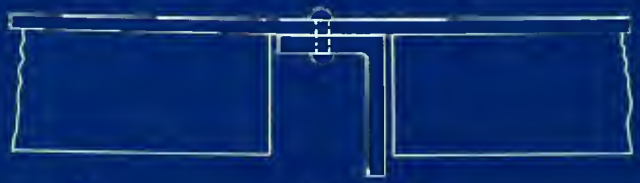
THE DESIGN OF THE COVER

After considering a method of moving the pans under the head after the pressure had been adjusted, and a method of enclosing the head and leading all the water off to the side until the pressure was adjusted, it was decided that the only way to shield the pans was to provide a cover which would just clear the top. The general shape of the cover was similar to that of the pans only larger. The framework was made of pipe fittings and light steel angles. On this framework was riveted a sheet of U. S. gauge number 26 galvanized iron which was turned up three inches on the radial sides to prevent spilling of the water when the cover was in motion. Allowance for drainage was made by making the middle point on the circumferencial side lowest. Wheels and a pivot were provided so that the cover could be rotated in a way similar to that of the pans. (See drawing of cover, also illustration of pans covered.)





SECTION X-X.



DETAIL A.

COVER AND DETAILS.
MAY 1915.
W.H.R. T.K.R.

CHAPTER V.

THE PLANE CEILING

The plane ceiling was made in two sections, each 4' x 8'. By means of clips fastened to the outer edge of each section, they were hung from rods on the ceiling so that the sections could be swung up into place, and the center edges fastened together forming a ceiling 8' x 8'. When the ceiling was in place the distance to the tops of the pans was eight feet, ten and a half inches (8'10 1/2"), the top of the pans being in reality the surface of the floor.

In order to easily estimate the amount of the ceiling wet by the spray, circles were drawn with the point directly over the head as a center. The diameter of these circles ranged from one (1) to eight (8) feet inclusive. They were painted white, the ceiling being black so as to show the wetted parts more clearly.

The side distribution was studied by the aid of rings hung from rods fastened to the corners of the ceiling and five (5) feet out from the head. The rings were placed as follows:- One, two (2) feet from the ceiling to study the distribution above this point. The distance of two feet was chosen because of rule three, Section S of the Rules and Requirements of the National Board of Fire Underwriters for Sprinkler Equipments.

"(3) Piling of Stock:- Sprinkler heads to be free to form an unbroken spray blanket for at least 2 feet under the ceiling from sprinkler to sprinkler and sides of the room. Any stock piles, racks or other obstructions interfering with such action are not permissable." Another ring was placed halfway between the 2' ring and the floor so that complete side distribution could be studied and the percentages of total discharge thrown between the rings and ceiling and floor

could be more accurately estimated. (See Part II, Test Method).

In order to make the tests under the various conditions found in practice, the distance of the deflector from the ceiling was made adjustable. Section B, rule 3 of the National Board Rules covers this point. "(3) Distance of deflectors from ceilings or bottom of joists to be not less than 3 inches nor more than 10 inches." This adjustment was secured by means of a slip joint just above the ceiling, and was operated by a rack and pinion. The pinion was at the end of a shaft about 15 feet long, and at the other end was attached an ordinary bicycle sprocket with a chain extending to another sprocket about 3 feet above the floor. This made adjustment from the floor possible.

CHAPTER VI

THE WATER SUPPLY SYSTEM

The essential factors of a good water supply system for test purposes consist of a non-pulsating supply capable of giving pressures as high as 150 pounds per square inch while delivering about 100 gallons of water per minute. It must be capable of sensitive adjustment to as low a pressure as five (5) pounds while discharging only ten gallons per minute.

The supply system used in the tests, consisted of a rotary pump taking its suction from a cistern of 12,000 gallon capacity, with a maximum suction lift for the pump of 10 feet. A 2 1/2 inch suction pipe was used with a total length of about 23 feet. The suction pipe also supplied a Quimby 50 gallon screw pump. Gate valves were used in each branch of suction piping to cut off one of the pumps when using the other. A single priming connection was used for both pumps. (See piping layout.) This connection was made to the Quimby pump, and when the rotary pump was to be primed, both gate valves in the suction branches were opened. After starting the rotary pump the gate valve leading to the Quimby was shut off to insure steady pressure, which would not be affected by the fluctuating city water supply used for priming.

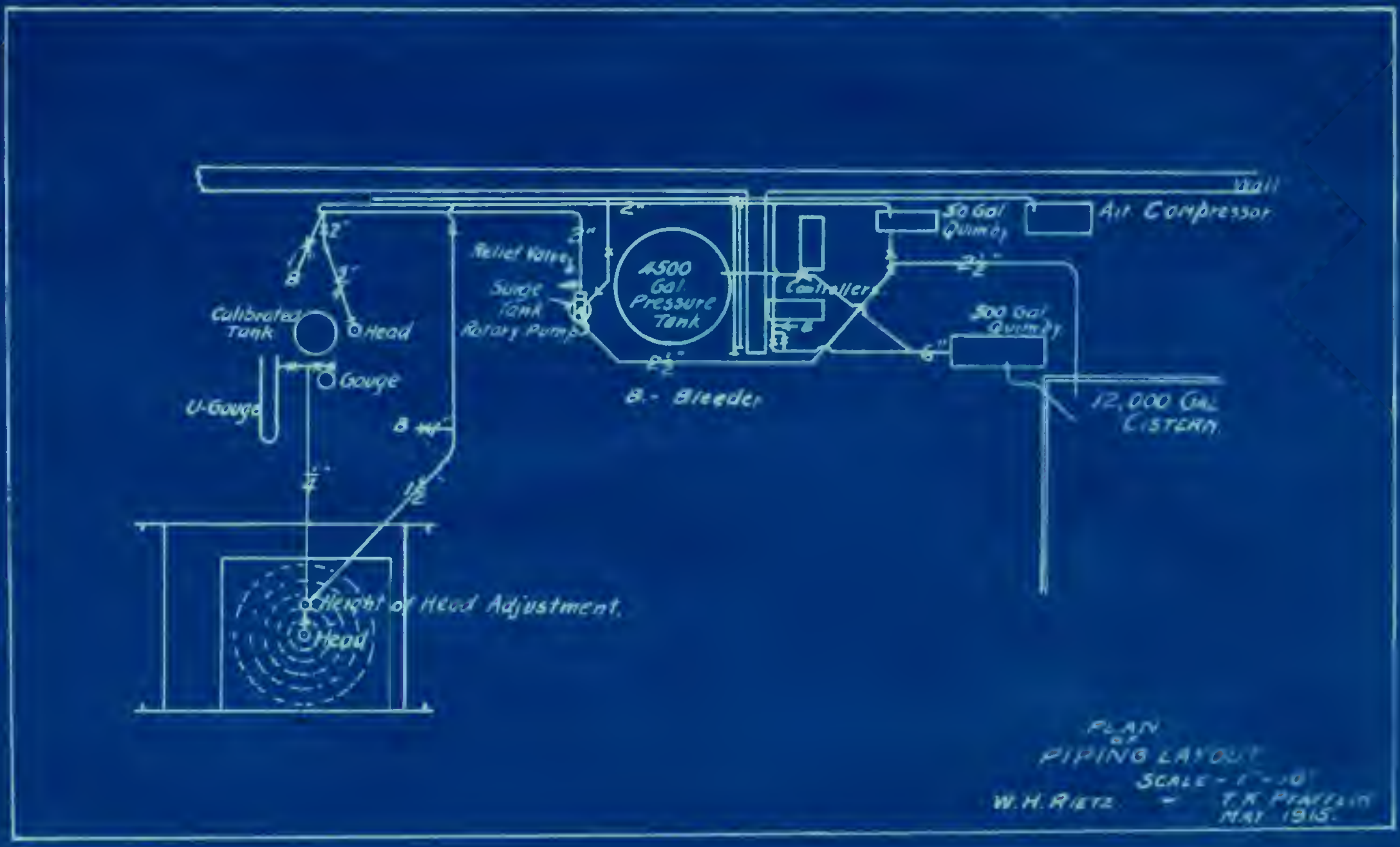
The pump was a gear pump with a maximum speed of about 400 R.P.M. The only motor available for driving the pump was a Northern variable speed motor rated at 5 H. P., with speeds ranging from 720 to 2160 R.P.M. A set of gears was made for connecting up the pump and motor, having a ratio of 5 to 1, the pinion being of rawhide in order to make them as nearly noiseless as possible.

Pump and Surge Tank.

The piping from the pump discharge was 2 inch, being reduced by gradual steps to 3/4" at the head. A relief valve was placed in the discharge line near the pump and adjusted to open at about 100 pounds per square inch. Pressure adjustments were made by means of two bleeders and by changing the speed of the motor. One of the bleeders discharged back into the cistern, and was used for all large adjustments, the other controlled by a 3/4" glove valve, was piped over to where it could be adjusted while watching the gauges, and was used for fine adjustments.

After making a few trial runs it was noticed that the pulsation was so great that the gauges could not be accurately read. In order to eliminate this a pulsation chamber of 6" pipe was made for the pump discharge. (See illustration of Pump and Surge Tank.) Into the top of the chamber was connected a pipe running to the air compressor used for maintaining an air cushion in the chamber. About 3' from the top of the chamber, just above the tee for the discharge piping was attached a petcock for getting the proper water level. The pulsation chamber was found to remove practically all pulsation.

The gauges for determining the flowing pressures at the head were connected by means of 1/4" pipe to a piezometer fitting close to the reducing elbow into which the head was screwed. For the lower pressures a seven (7) foot mercury gauge was used.


Wall
Air Compressor
50 Gal. Quimby
2"
2"
3"
Relief Valve
Surge Tank
Rotary Pump
4500 Gal. Pressure Tank
Controller
$2\frac{1}{2}$"
$2\frac{1}{2}$"
500 Gal. Quimby
6"
12,000 Gal. Cistern
B.- Bleeder
B
Calibrated Tank
Head
Gauge
U-Gauge
B
$\frac{1}{2}$"
$1\frac{1}{2}$"
Height of Head Adjustment.
Head
PLAN OF PIPING LAYOUT
SCALE - 1" = 10'
W. H. RIETZ - T. K. PFAFFLIN
MAY 1915.

CHAPTER VII

THE DISCHARGE CALIBRATION

In order to find what percent of the water thrown from the head was collected in each zone and sector, it was necessary to calibrate the head, that is to determine the quantity of water that the sprinkler was discharging at various pressures.

The apparatus designed for this purpose, consists of a calibrated tank; a hood for collecting the discharge from the head and diverting it into the tank; and a swinging pipe made by using two 90 degree elbows, for moving the hood over the tank while making a run and removing it at the close of the run.

The calibrated tank was merely a cylindrical tank about six (6) feet high and three (3) feet in diameter, having a capacity of 250 gallons. A gauge glass with a scale graduated in gallons was mounted on the outside of the tank. The hood was cylindrical, about 1 foot in diameter and 2 feet high, with top covered so that water discharged from the head could get out only at the bottom and fall into the tank. The hood was supported on the swinging pipe and could easily be removed for changing heads. The pipe enters the hood at the side, and holds the head upright inside the hood. The piezometer ring was also inside the hood and was attached to the gauges by means of flexible rubber tubing.

Apparatus for the Head Calibration.

PART II. THE APPLICATION

CHAPTER I.

THE TEST METHOD.

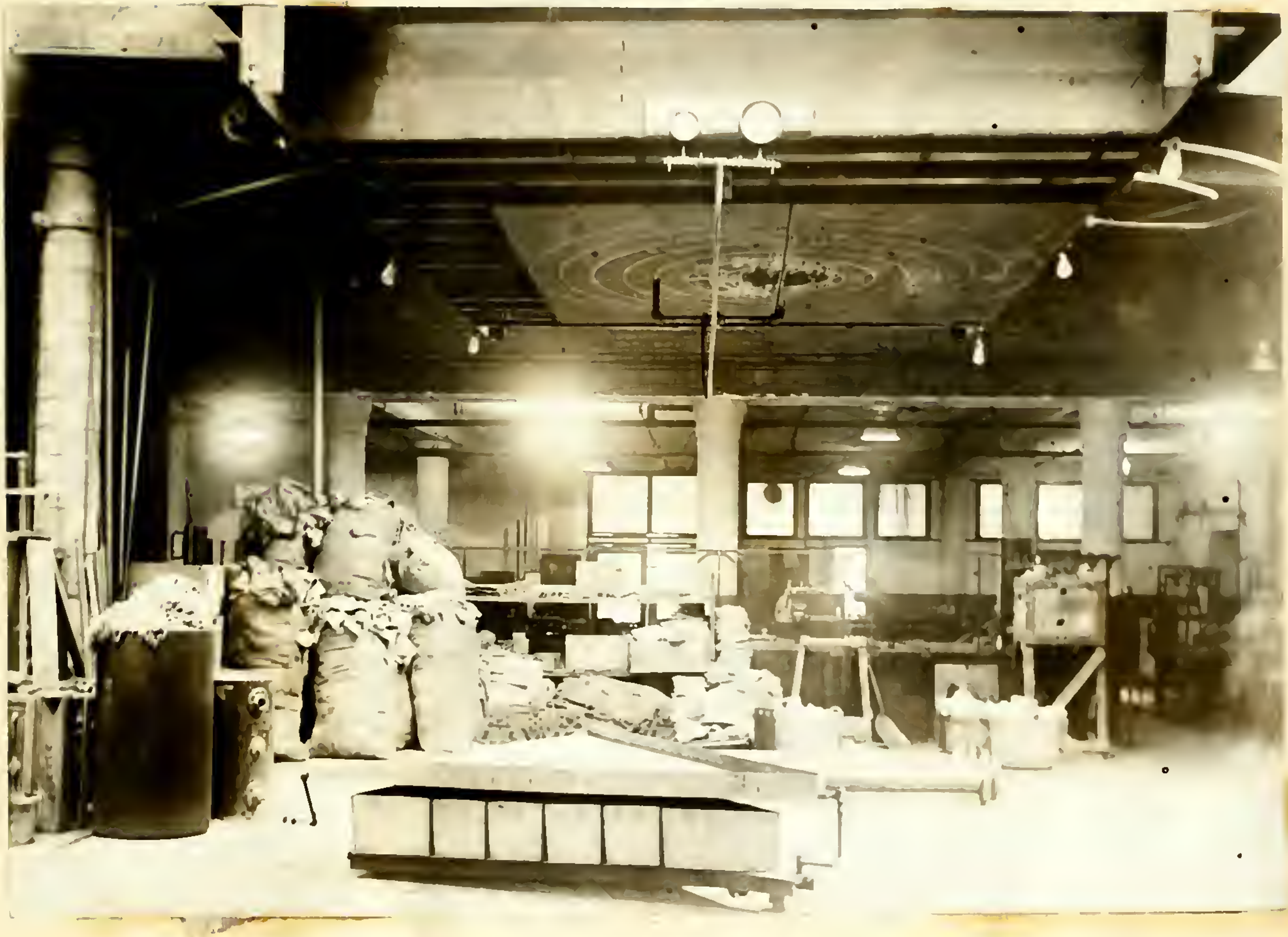
In determining a method for making tests, the main idea was to devise a method by which the actual distribution could be measured, and after a number of heads had been tested and the results compared, a standard could be set by which all sprinklers could be judged.

The time required for making tests and the amount of labor required were also considered as important factors governing the method to be used. The method finally adopted consists of two distinct series of tests; first, the determination of the discharge curve for each sprinkler to be tested; second, the actual distribution tests.

Discharge Calibration:- The discharge calibration was conducted as follows:- The piezometer fitting was attached to the test piping described in Part I under Discharge Calabration, and the head was screwed into the elbow next to the piezometer. The piezometer ring was then connected to the gauges by means of flexible rubber tubing, and the hood applied. The pipe was then swung to one side so that the water could go to waste while the pressure was being adjusted. The tank reading and the necessary corrections for pressure were then taken, and the pump started. After the pressure had been adjusted by means of the bleeders and the motor control, the hood was swung to a position over the tank, the time being taken on a stop watch. After about 150 to 200 gallons had been collected the hood was swung to one side, snapping the stop watch at the same time. From this data by means of five pound (5#) steps, a calibration curve was plotted.

Distribution Tests:- The head and piezometer fittings were next removed from the discharge apparatus and attached to the piping at the ceiling for distribution tests. The height of the head was adjusted until

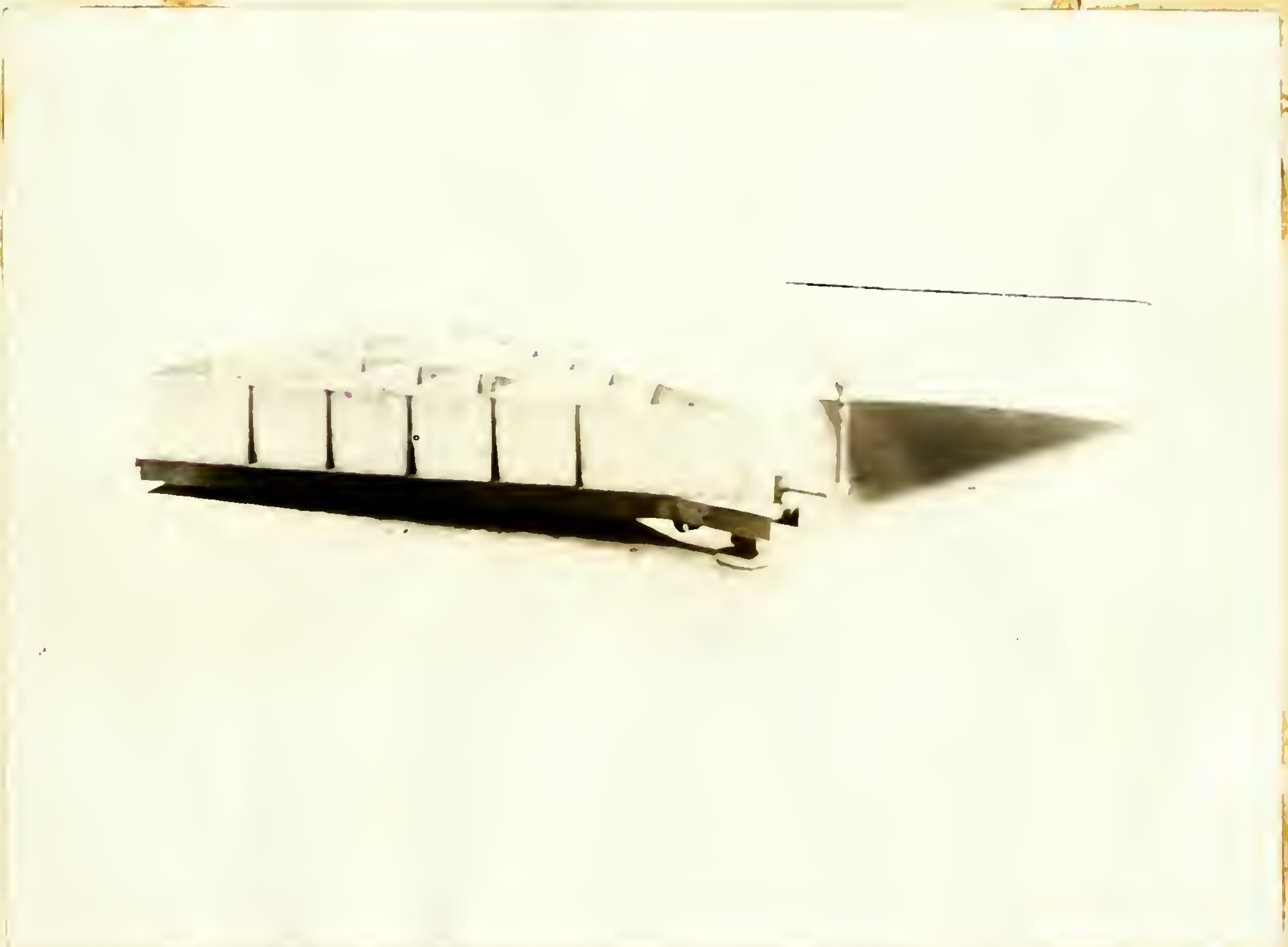
Pans Covered, Ready for Test.



the deflector was exactly three inches below the ceiling. The pivot, frame, pans, and cover were placed in Position I. (See Diagram). By means of the marking on the floor they could be accurately placed so that the tip of pan number 12 was directly under the head. The piezometer ring was connected to the gauges by means of a long pipe 1/4 inch in diameter. With the cover in position over the pans, the pump was started and the pressure adjusted to about five pounds (5#) per square inch at the head of the first test. The pans were now uncovered by moving the cover at a uniform rate partly around the circle. Time was taken on the stop watch when the first pan was uncovered and again when the cover was being run over the first pan. The interval of time between the two constituted a run. The length of the run depended upon the pressures and for five pounds was about eighteen minutes, for thirty pounds twelve minutes, and for ninety pounds about eight minutes. The pump was now stopped and the pans and water were weighed and again set up, the frame being moved to Position II. After a set of eight runs had been made, one in each position, another set of runs were made with the same pressure, but with the head lowered so that the deflector was six inches from the ceiling. A third set of runs was next made with the deflector ten inches from the ceiling. The above three sets constitute a series for the head at one pressure. Three different pressures were taken with the head tested, making nine sets of runs in all.

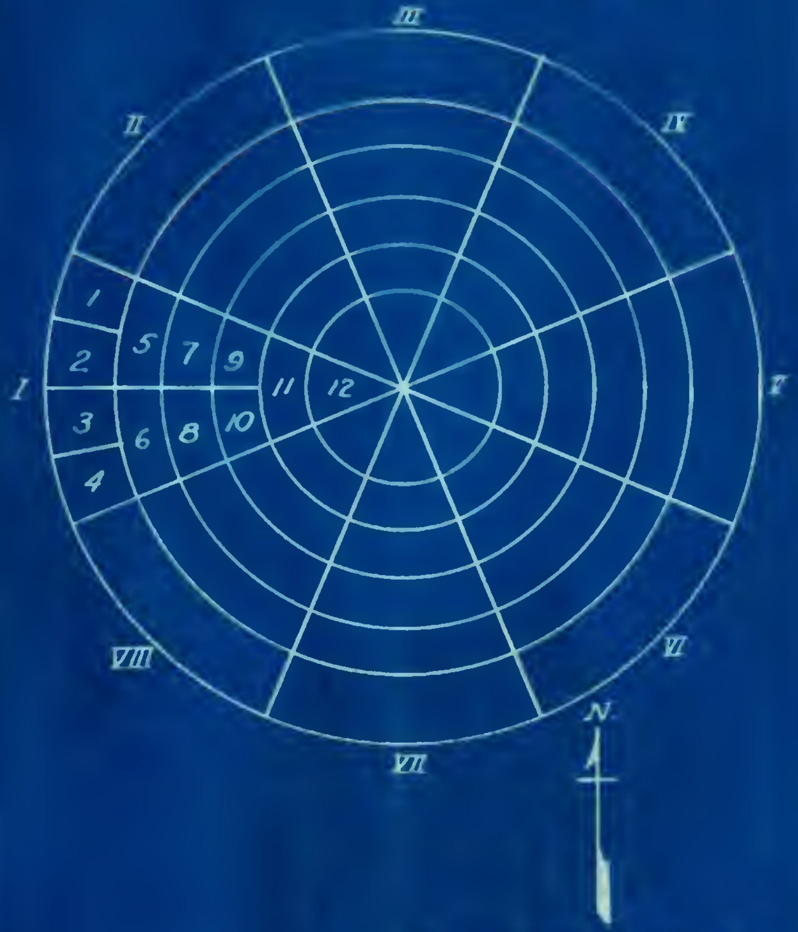
Notes on side and ceiling distribution were taken whenever a change was made in either pressure or the position of the deflector. The notes consisted of estimates on the area of ceiling struck by the spray from the sprinkler, and the area of that part of the ceiling from which dripping occurs. For side distribution, they consisted of estimates of the relative amounts of water thrown; first, over the two foot ring hung from the ceiling; second, between the two foot and four foot five and one half inch ring. Notes were also taken during the runs on the form of the water thrown from the head, that is, the form of the drops.

Pans Exposed.



From the data taken in the above tests, the distribution in zones from the center or point directly under the head was calculated and a diagram made showing this distribution. Another diagram showing the percent of water thrown in each sector was plotted.

After tests have been made with a number of heads, standard diagrams can be made showing the minimum percentages thrown in any sector, and the minimum distribution in the different zones, so that a testing standard may be obtained



PLAN SHOWING RELATION
OF
POINTS OF COMPASS,
POSITION OF PANS,
AND
NUMBER OF PANS.
SCALE 1" 4'.
MAY 1915.
RP WHR

CHAPTER II.

SAMPLE CALCULATIONS.

Total number of gallons---------------------------117.
Length of run in minutes-------------------------- 10.
Discharge, gal. per min.-------------------------- 11.7
Difference in height of Hg column---------------- 10.7"

Equivalent pressure in feet head=
(10.7 x 13.57) ÷ 12" = 12.09'

Diameter of piezometer tube = .825".
Velocity of water thru the tube =
Q (Cubic feet per sec.) ÷ Area (Sq. Ft.)

$$v = \frac{Q' \text{ (Gal. per Min.) } \times 231}{60 \times (1/4)\pi \times (.825)^2 \times 12} = .6\ Q' \text{ in Gal. per Min.}$$

$$\text{Velocity head } h = \frac{v^2}{2g} = \frac{Q'^2 \times .36}{64.32} = .00559(Q'^2 \text{ Gal. per Min}) = h' \text{ in ft.}$$

Q' in run #1 = 11.7 Gal. per Min.
Therefore, velocity head = .00559 x 11.7^2 = .765'.

Water Corrections.

Height of piezometer above zero of gauge 76.0"
Height of Hg on Right -------------------- 30.2"
Correction on Right ---------------------- 45.8"
Height of water on Left ------------------ 72.3"
Height of Hg on Left --------------------- 40.9"
Water Correction on Left ----------------- 31.4"

Water Correction = 45.8-31.4 = 14.4" = 1.2'.

Effective Pressure = 12.09 + .765-1.2 = 11.655'

Effective Pressure in Pounds per Sq. In.=
11.655 ÷ 2.31 = 5.045 #/In.^{2}

DISTRIBUTION CALCULATIONS

SET #I.

Difference in Height of Hg Columns----------------16.6"
Equivalent Pressure in Feet Head = 16.6 x 1.13 = 18.758'
Height of Piezometer above zero--------------9' = 108".
Height of Hg on Left----------------------------- 35.6"
Correction Left---------------------------------- 72.4"

Correction Right = 72.3-52.2 = ------------------ 20.1"
Water Correction--------------------------------- 52.3"
Water Correction in Feet------------------------- 4.358'
Indicated Pressure = 18.758-4.358 = ------------- 14.4'
Velocity Head Determined from Curve-------------- 1.13'
Effective Head in Feet ---- --------------------- 15.53'
Effective Head in Pounds per Sq. In.------------- 6.723
Total Discharge in Gal. per Min from
Curve at 6.723#/In^{2} = ------------------------- 14.0
Theoretical Discharge per Min. in each Sector
= 14.0 ÷ 8 = 1.75

The first data sheet in each set contains weights of water in each pan found by subtracting the weight of pan from the weight of the pan plus the water.
Set #1, Pan #1, Run #1 22:10-13:2 = 9:8.

The second data sheet contains the weights of water per pan per minute and is found by dividing the total weight of water in pan by the length of the run.
Set #1, Run #1, Pan #1 9:8 or 9.5# ÷ 17.84 Min. = .550 lbs. per min. in Pan #1.
The total weight collected per minute in all positions of pans is then added together. Then the total in each zone is added together as Pans #1, #2, #3 and #4 to find the total amount of water thrown in the 6-7 1/2 foot zone.
Total weights in zones is changed to Gal. per Min. by dividing by 8.35 which is the weight of a gallon of water in pounds at eleven degrees Centigrade.

Zone 6-7 1/2 = 11.983 ÷ 8.35 = 1.435 Gal. per Min.

To find the Gallons per square foot per minute, the number of gallons per minute are divided by the area of the zone.
Area of the 6-7 1/2 ft. zone = 63.61 sq. ft.
Gallons per square foot per minute in zone 6-7 1/2
= 1.435 ÷ 63.61 = .0226.
Percentage of total discharge thrown in 6-7 1/2 ft. zone equals (1.435 ÷ 14.0) x 100 = 10.25%.

To find the percentage of the theoretical amount thrown in each sector, the weights of the water per minute in all twelve pans are added.

Set #1, Run #1, Weight in 12 Pans per Min. = 9.743.
Gallons per Minute in 12 Pans = 9.743 ÷ 8.35 = 1.17 Gal.
Percentage of theoretical = 1.17 ÷ 1.75 x 100 = 66.9%.

SIDE DISTRIBUTION.

Total Percentage thrown outside of rings = Zone 5-6 plus Zone 6-7 1/2 plus the percent thrown outside the pans total side distribution.
In Set #1, this equals 10.37 plus 10.25 plus 20.0
= 40.62%.
From notes, one-half of the water thrown out goes over the two foot ring, therefore the percent over the two foot ring = 1/2 x 40.62 = 20.31%.
Three-eighths is thrown between the rings
= 3/8 x 40.62 = 5.05%.
One-eighth is thrown under the 4'-5 1/2 ring = 1/8 x 40.62 = 5.05%.

CHAPTER III.

TEST DATA:-

GAUGE CALIBRATION
LIMITS - 0-250 #/IN²

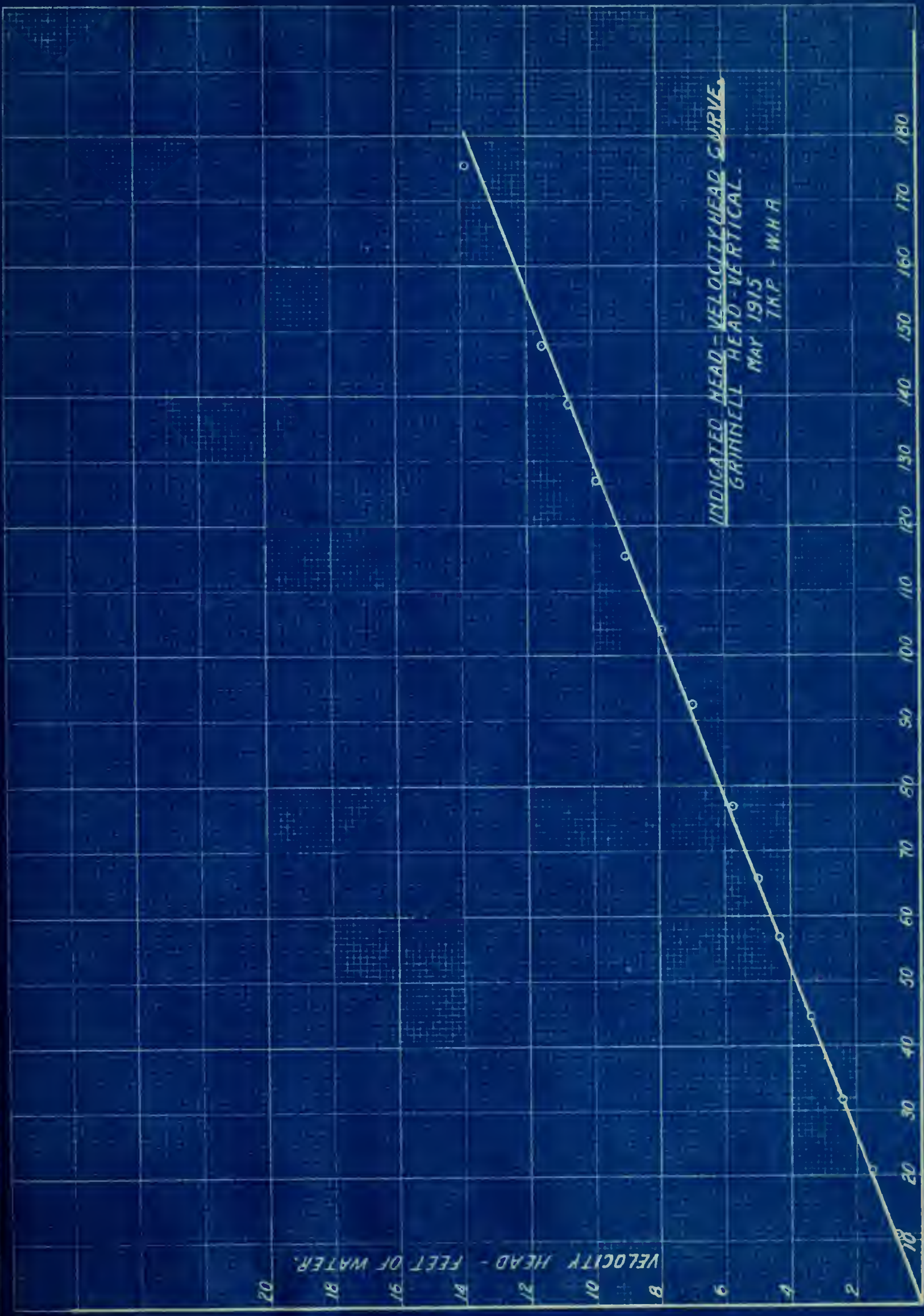
TRUE PRESSURE #/IN²	GAUGE READING #/IN²
00	00
5	5
10	10
15	15.5
20	20.5
25	25.5
30	31
35	36
40	41
45	46
50	51
55	56
60	61
65	66
70	71
75	76
80	81.5
85	86.5
90	91.5
95	96
100	101
105	106
110	111
115	115.5
120	120
125	125
130	130
135	135
140	139
145	144
150	148.5

CALIBRATION OF GRINNELL HEAD.

VERTICAL POSITION

HEIGHT OF PIPE FROM ZERO OF GAUGE SCALE - 76.0

TIME	GALLONS.				PRESSURE.											
MIN-SEC.	INIT.	FINAL	DIFF.	PER MINUTE	HG. Left Inches	HG. Rt. Inches.	H_2O Lt. Inches	H_2O.Cor. Left	H_2O Rt. Inches	H_2O Cor DIFF.	HG - FT. H_2O	HG. Diff. In.	Vel. Head. Ft.	Indicated Head. Ft.	Effective Head. Ft.	Eff. Pres. #/in²
10-00	30	147.0	117.0	11.7	40.9	30.2	72.3	31.4	45.8	-14.4	12.09	10.7	.765	10.89	11.655	5.045
10.00	27.7	195.3	167.6	16.76	44.8	25.0	76.3	31.5	51.0	-19.5	22.37	19.8	1.57	20.75	22.32	9.66
9-00	20.6	208.0	187.4	20.82	49.0	19.0	80.7	31.7	57.0	-25.3	33.9	30.0	2.42	31.79	34.21	14.81
8-00	24.3	221.8	197.5	24.69	53.9	11.9	82.6	28.7	64.1	-35.4	47.46	42.0	3.41	44.51	47.92	20.74
7-00	17.1	212.4	195.3	27.90	66.3	12.6	83.1	16.8	63.4	-46.6	60.68	53.7	4.35	56.8	61.15	26.47
6-00	27.2	207.6	180.4	30.07	70.0	7.9	82.1	12.1	68.1	-56.0	70.173	62.1	5.05	65.5	70.55	30.54
7-00	18.6	244.0	225.4	32.2	75.5	2.3	81.1	5.6	73.7	-68.1	82.716	73.2	5.8	77.04	82.84	35.86
					Gauge #/in²	Corrected #/in²										
5-00	18.4	196.0	177.6	35.52	41.0	40.0							7.053	92.4	99.45	43.05
5-00	18.2	206.5	188.3	37.66	46.0	45.0							7.93	103.95	111.88	48.43
5-00	20.5	221.5	201.0	40.2	51.0	50.0							9.034	115.50	124.53	53.91
4-00	25.0	193.6	168.6	42.15	56.0	55.0							9.931	127.05	136.98	59.3
4-00	15.8	191.4	175.6	43.9	61.0	60.0							10.77	138.60	149.37	64.66
4-00	16.5	198.5	182.0	45.5	65.0	64.0							11.57	147.84	159.41	69.01
3-00	36.5	186.0	149.5	49.83	77.0	76.0							13.88	175.56	189.44	82.01


INDICATED HEAD - VELOCITY HEAD CURVE.
GRINNELL HEAD - VERTICAL.
MAY 1915
T.K.P. - W.H.A.
VELOCITY HEAD - FEET OF WATER.
2
4
6
8
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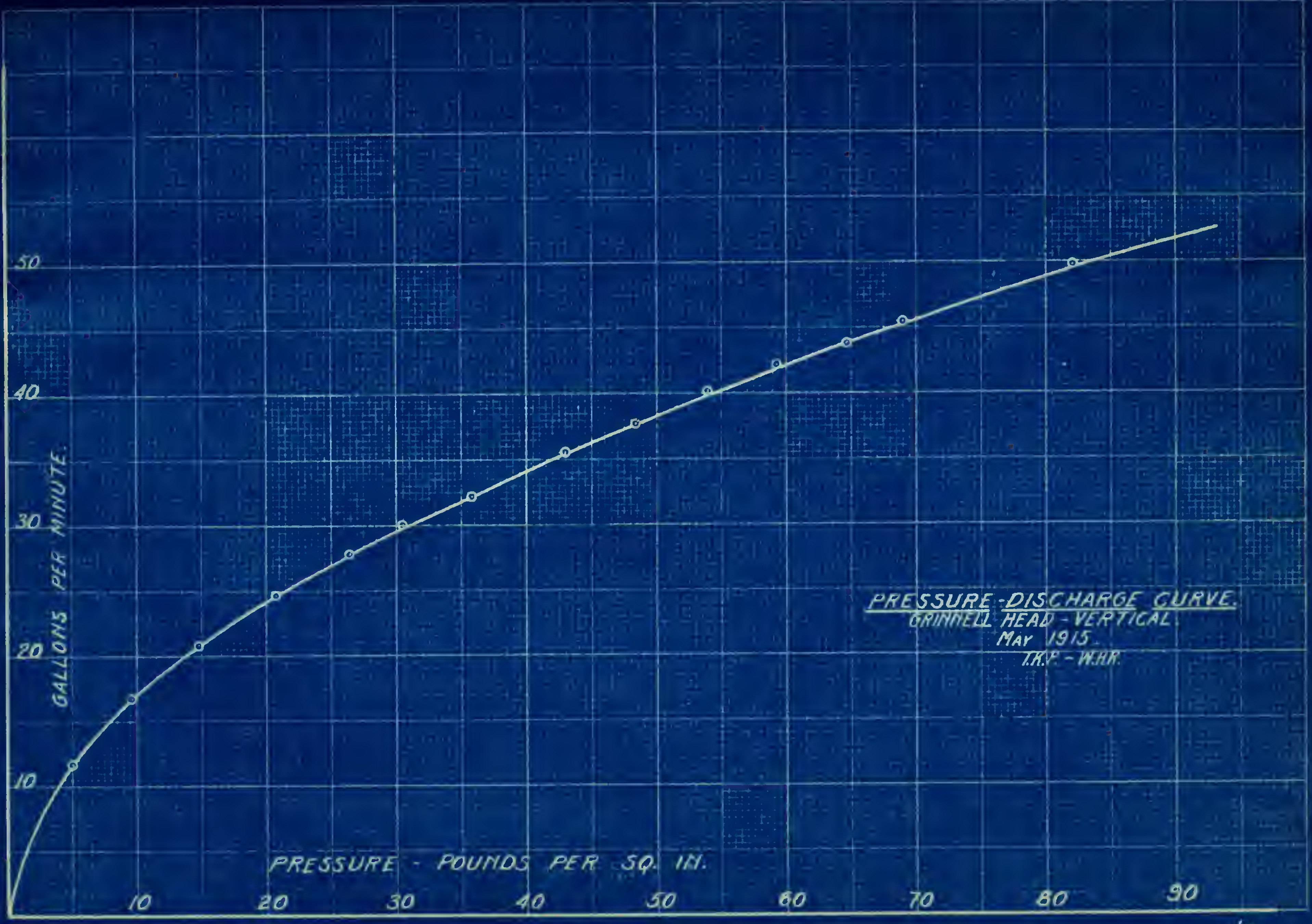

PRESSURE-DISCHARGE CURVE.
GRINNELL HEAD - VERTICAL
MAY 1915.
T.K.P. - W.H.R.

TEST DATA SET #I

GRINNELL HEAD UPRIGHT 3" FROM CEILING. PLAIN CEILING.
PRESSURE - {EFFECTIVE - 6.723 #/IN.² ; FLOWING - 6.234 #/IN.²}
DISCHARGE - 14.0 GAL/MIN.

RUN NUMBER	1	2	3	4	5	6	7	8
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME - MIN. SEC.	17:50$\frac{2}{5}$	17:56	17:52$\frac{1}{5}$	17:49	12:50$\frac{1}{5}$	17:45	13:49	14:48$\frac{1}{5}$
EFFECTIVE PRESSURE #/in.²	6.723	6.723	6.723	6.723	6.723	6.723	6.723	6.723
WT. WATER IN PAN 1 #-OZ.	9:8	7:10	3:11	6:2	5:1	4:8	6:11	3:10
PAN 2	4:4	10:0	7:12	8:14	4:1	3:4	5:2	4:9
PAN 3	6:7	7:13	6:3	6:1	6:13	4:7	4:9	7:0
PAN 4	8:1	8:0	4:12	3:5	5:13	8:1	4:7	7:12
PAN 5	10:12	25:5	11:14	10:12	6:7	10:3	14:13	7:3
PAN 6	11:0	16:13	18:5	10:9	9:11	8:9	9:10	14:11
PAN 7	8:9	26:1	17:1	13:1	8:2	13:10	18:0	7:10
PAN 8	9:5	14:7	41:2	8:3	11:15	10:1	17:9	13:5
PAN 9	8:10	12:12	12:5	16:11	15:8	9:6	10:2	7:15
PAN 10	10:0	9:6	14:11	10:8	24:13	25:9	14:15	14:4
PAN 11	55:10	45:5	37:11	62:0	58:0	78:8	76:5	78:1
PAN 12	31:10	17:3	19:9	11:0	6:9	38:0	23:2	20:2

TEST DATA - SET # 1.

TIME - 1 MIN. 0 SEC.

RUN NO.	1	2	3	4	5	6	7	8	TOTALS	WEIGHT IN ZONES LBS	GALLONS IN ZONES	AREA OF ZONES FT.²	GAL./SQ.FT. PER MIN. IN ZONES	PER CENT IN ZONES.
POSITION OF PANS.	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	14.0					
WT. WATER IN PAN 1/MIN.	.55	.425	.206	.344	.394	.253	.497	.245	2.914					
PAN 2.	.238	.558	.434	.498	.316	.183	.375	.308	2.910	ZONE 6-7½				
PAN 3.	.360	.435	346	.340	.530	.243	.330	.473	3.060	11.983	1.435	63.61	.0226	10.25
PAN 4	.452	.447	.265	.185	.452	.454	.320	.524	3.099					
PAN 5	.603	1.410	.665	.603	.496	.574	1.070	.485	6.006	ZONE 5-6				
PAN 6	.617	.940	1.025	.592	.754	.482	.696	.992	6.098	12.104	1.45	34.56	.042	10.37
PAN 7	.48	1.45	.955	.733	.632	.768	1.30	.52	6.838	ZONE 4-5				
PAN 8	.52	.805	2.30	.458	.93	.567	1.27	.90	7.750	14.588	1.75	28.275	.062	12.5
PAN 9	.483	.71	.69	.935	1.21	.528	.735	.536	5.827	ZONE 3-4				
PAN 10	.56	.523	.82	.59	1.93	1.44	1.08	.964	7.907	13.734	1.648	21.991	.075	11.76
PAN 11	3.11	2.53	2.11	3.48	4.50	4.42	5.50	5.27	30.92	ZONE 2-3 30.92	3.71	15.708	.236	26.5
PAN 12	1.77	.96	1.095	.617	.51	2.14	1.68	1.36	10.132	ZONE 0-2 10.132	1.217	12.566	.097	8.7
TOTALS	9.743	11.193	10.911	9.375	12.654	12.055	14.853	12.577						
GALLONS	1.17	1.34	1.308	1.123	1.516	1.445	1.78	1.51			11.18			
PER CENT	67.0	76.0	74.7	64.3	86.7	82.6	101.7	86.0			80.0			

TEST NOTES - SET NO. 1.

Side Distribution:- Of the total water discharged by the sprinkler head, 40.62% was thrown outside of the ring which were five (5) feet in radius.

20.31% of the total discharge was thrown over the ring two (2) feet from the ceiling,
15.23% was thrown between the rings two (2) feet and four feet five and one half inches (4'-5 1/2"), and
5.08% was thrown under the four foot five and one half inch ring.

Ceiling Distribution:- Ceiling above head in two (2) foot diameter circle was struck by spray, heavy drops coming from circle five (5) feet in diameter.

Form of Discharge:- Large Drops, no mist.

TEST DATA - SET #2.

GRINNELL HEAD UPRIGHT 6" FROM CEILING
PRESSURE - {EFFECTIVE - 6.83 #/IN² / FLOWING - 6.35 #/IN²}

PLAIN CEILING.
AVERAGE TIME - 17 MIN. - 50 SEC.
DISCHARGE - 14.1 GAL/MIN.

RUN NUMBER	9	10	11	12	13	14	15	16.
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME - MIN. - SEC.	17:49	17:50	17:51	17:51	17:51	17:50	17:49	17:50
EFFECTIVE PRESSURE #/in²	6.83	6.83	6.83	6.83	6.83	6.83	6.83	6.83
WT. WATER IN PAN 1 #.OZ.	9:14	7:11	3:10	5:12	8:5	4:14	8:7	5:4
PAN 2	4:14	10:3	7:8	8:6	5:10	2:15	6:0	6:3
PAN 3	6:0	6:0	6:13	7:4	9:11	4:3	7:3	9:6
PAN 4	10 13	8:4	4:14	3:12	7:11	9:9	8:0	10:1
PAN 5	11:7	25:2	11:4	10:14	11:11	10:15	19:5	10:4
PAN 6	10:9	16:13	17:3	12:8	14:0	11:0	15:4	21:1
PAN 7	8:6	27:10	15:8	13:2	17:4	16:11	25:5	11:1
PAN 8	7:13	14:7	41:11	10:8	20:6	15:6	26:5	20:3
PAN 9	8:0	13 13	11:11	19:6	33:10	13:13	15:14	12:13
PAN 10	12:11	8:6	5:13	21:3	41:11	35:11	32:7	40:12
PAN 11	35:6	29:7	30:2	40:14	40:14	53:10	71:0	48:6
PAN 12.	28:13	15:9	11:2	7:10	7:13	17:13	17:1	9:15

TEST DATA. - SET #2 TIME - 1 MIN - 0 SEC.

RUN NO.	9	10	11	12	13	14	15	16	TOTALS	WEIGHT IN ZONES LBS.	GALLONS IN ZONES	AREA OF ZONES FT.²	GAL./SQ.FT. PER MIN IN ZONES	PER CENT IN ZONES
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	14.1					
WT. WATER IN PAN 1 / MIN	.555	.430	.203	.321	.465	.274	.473	.294	3.015					
PAN 2	.274	.571	.420	.469	.315	.165	.336	.347	2.897	ZONE 6-7½				
PAN 3	.336	.336	.381	.406	.542	.235	.403	.525	3.164	12.607	1.51	63.61	.0238	10.7
PAN 4	.607	.462	.273	.210	.431	.536	.449	.563	3.531					
PAN 5	.642	1.408	.630	.610	.655	.614	1.082	.575	5.216	ZONE 5-6				
PAN 6	.592	.943	.962	.700	.784	.617	.857	1.180	5.635	10.851	1.30	34.56	.0376	9.23
PAN 7	.470	1.550	.870	.739	.967	.935	1.420	.620	7.571	ZONE 4-5				
PAN 8	.438	.810	2.330	.588	1.140	.862	1.475	1.130	8.773	16.344	1.958	28.275	.0693	13.9
PAN 9	.449	.775	.655	1.083	1.883	.775	.890	.719	7.229	ZONE 3-4				
PAN 10	.712	.469	.325	1.186	2.330	2.000	1.820	2.283	11.125	18.354	2.200	21.991	.1001	15.6
PAN 11	2.000	1.651	1.690	2.730	2.290	3.000	3.980	2.718	20.059	ZONE 2-3 20.059	2.400	15.708	.1528	17.0
PAN 12	1.617	.873	.627	.427	.437	.999	.956	.556	6.492	ZONE 0-2 6.492	.778	12.566	.062	55.2
TOTAL	8.692	10.278	9.066	9.469	12.239	11.012	14.141	11.510						
GALLONS	1.04	1.23	1.085	1.132	1.467	1.32	1.695	1.379			10.146			
PER CENT	59.2	70.0	61.6	64.4	83.2	75.0	95.3	78.3			72.0			

TEST NOTES - SET NO. 2.

Side Distribution:- Of the total water discharged by the sprinkler head, 47.93% was thrown outside the rings which were five (5) feet in radius.

29.9% of the total discharge was thrown over the ring two (2) feet from the ceiling.

11.98% was thrown between the rings two (2) feet and four feet five and one half inches (4'-5 1/2"), and

6.05% was thrown under the four foot five and one half inch (4'-5 1/2") ring.

Ceiling Distribution:- Ceiling above in three (3) foot diameter circle was struck by the spray, heavy drops coming from the circle six (6) feet in diameter.

Form of Discharge:- Large Drops, no mist.

TEST DATA - SET #3.

GRINNELL HEAD UPRIGHT 10" FROM CEILING. PLAIN CEILING

PRESSURE - {EFFECTIVE 6.97 #/IN.² ; FLOWING #/IN.²} DISCHARGE - 14.25 GAL./MIN.

RUN NUMBER.	17	18	19	20	21	22	23	24
POSITION OF PANS.	I	II	III	IV	V	VI	VII	VIII
TIME. MIN. - SEC.	17:50	17:48	17:50	17:50	17:48	17:48	16:56	17:41
EFFECTIVE PRESSURE #/IN.²	6.97	6.97	6.97	6.97	6.97	6.97	6.97	6.97
WT. WATER IN PAN 1 #:OZ.	10:7	7:5	3:12	6:3	8:0	5:0	8:1	5:6
PAN 2	5:1	10:6	8:2	9:0	6:8	3:2	5:11	6:9
PAN 3	6:12	8:4	7:1	6:12	10:2	4:5	5:8	9:11
PAN 4	9:4	8:4	4:11	5:9	7:5	10:5	7:12	9:12
PAN 5	11:11	23:12	11:4	10:12	12:14	11:6	18:1	10:2
PAN 6	11:3	16:14	15:3	11:4	13:10	12:4	15:3	20:3
PAN 7	8:4	29:6	16:3	12:9	23:13	19:0	19:9	10:13
PAN 8	8:13	15:9	42:10	8:12	27:3	31:6	28:3	20:5
PAN 9	7:7	11:14	11:3	18:0	31:1	24:6	15:5	15:0
PAN 10	10:3	8:12	17:4	16:11	29:2	27:9	53:1	40:4
PAN 11	18:10	15:9	18:8	21:15	20:4	40:12	32:12	26:15
PAN 12	32:4	14:7	8:5	6:10	8:4	9:13	9:15	9:0

TEST DATA - SET #3

TIME - 1 MIN. 0 SEC.

RUN NO.	17	18	19	20	21	22	23	24	TOTALS	WEIGHT IN ZONES LBS.	GALLONS IN ZONES	AREA OF ZONES FT²	GAL/SQ.FT. PER MIN. IN ZONES	PERCENT IN ZONES.
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	14.25					
WT. WATER IN PAN 1/MIN.	.586	.422	.210	.346	.450	.281	.475	.320	3.090					
PAN 2	.284	.583	.455	.505	.365	.176	.336	.371	3.025	ZONE, 6-7½				
PAN 3.	.378	.463	.396	.379	.568	.242	.325	.548	3.299	12.976	1.552	63.61	.0244	10.9
PAN 4.	.518	.463	.269	.312	.411	.580	.457	.552	3.562					
PAN 5	.655	1.335	.631	.603	.723	.640	1.065	.573	5.225	ZONE 5-6				
PAN 6	.627	.948	.851	.632	.766	.688	.897	1.140	6.549	11.774	1.41	34.56	.0408	9.9
PAN 7	.462	1.648	.908	.705	1.327	1.067	1.155	.612	7.884	ZONE 4-5				
PAN 8	.494	.875	2.388	.490	1.525	1.760	1.663	1.150	10.345	18.229	2.185	28.275	.0773	15.3
PAN 9	.417	.667	.627	1.008	1.743	1.368	.905	.850	7.583	ZONE 3-4				
PAN 10	.570	.492	.967	.935	1.633	1.548	3.130	2.277	11.552	19.135	2.293	21.991	.1043	16.1
PAN 11	1.104	.875	1.037	1.229	1.137	2.290	1.933	1.522	11.127	ZONE 2-3 11.127	1.333	15.708	.085	9.37
PAN 12	1.817	.812	.466	.371	.463	.551	.587	.508	5.575	ZONE 0-2 5.575	.668	12.566	.0532	4.7
TOTALS	7.912	9.583	9.205	7.515	11.167	11.191	12.928	10.423						
GALLONS	.948	1.147	1.102	.900	1.336	1.340	1.55	1.25			9.573			
PERCENT	53.2	64.6	61.8	50.6	75.0	75.3	87.0	70.2			66.3			

TEST NOTES - SET NO. 3.

Side Distribution:- Of the total water discharged by the sprinkler head, 54.5% was thrown out side the rings which were five feet (5') in radius.

36.3% of the total discharge was thrown over the ring two(2) feet from the ceiling.

12.1% was thrwon between the rings two (2) feet and four feet five and one half inches (4'-5 1/2")/ and

6.1% was thrown under the four foot five and one half inch (4'-5 1/2") ring.

Ceiling Distribution:- Ceiling above head in four (4) foot diameter circle was struck by the spray, heavy drops coming from the circle seven (7) feet in diameter.

From of Discharge:- Heavy Drops, no Mist.

TEST DATA · SET #4.

GRINNELL HEAD UPRIGHT 3" FROM CEILING
PLAIN CEILING
PRESSURE - EFFECTIVE 30.53 #/IN.^{2}
FLOWING #/IN.^{2}
DISCHARGE - 30.06 GAL/MIN

RUN NUMBER	25	26	27	28	29	30	31	32.
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME - MIN. SEC.	11:59	11:59	12:01	12:00	11:59	12:02	11:55	12:01
EFFECTIVE PRESSURE #/IN.^{2}	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53
WT. WATER IN PAN 1 #-OZ.	13:8	25:14	5:0	10:4	11:14	5:1	14:12	4:2
PAN 2.	7:6.	21:13	10:14	15:6	8:8	3:1	8:14	6:0
PAN 3	13:8	11:2	14:11	7:0	20:4	5:12	7:10	13:5
PAN 4	10:6	9.9	14:14	3.9	19:6	20:2	8:2	18:7
PAN 5	18:9	44:4	17:4	28:13	20:12	9:13	28:7	8:13
PAN 6	21 12	18 10	43 15	16 00	46:0	35:0	23:0	30:0
PAN 7	32:9	46:1	24:9	38:0	47:14	12:8	30:15	12:15
PAN 8	39:11	17:9	38:8	20:5	50:15	45:9	57:3	59:13
PAN 9	24:4	28:1	28:4	32:13	41:5	27:4	32:2	33:1
PAN 10	27:4	21:6	24:2	16:15	27:0	30.3	65:14	47:5
PAN 11	22:1	34:9	47:9	17:13	11:14	56:0	41:2	41:13
PAN 12	48:4	25:6	12:6	11:8	9:10	11:0	12:9	14:15

TEST DATA - SET #4.

TIME - 1 MIN. 0 SEC.

Run No.	25	26	27	28	29	30	31	32	Totals	Weight in Zones Lbs.	Gallons in Zones	Area of Zones Ft.^{2}	Gal/Sq Ft Per Min in Zones	PerCent in Zones
Position of Pans	I	II	III	IV	V	VI	VII	VIII						
Total Discharge	3.76	3.76	3.76	3.76	3.76	3 76	3.76	3.76	30.06					
Wt. Water in Pan 1/Min	1.126	2.148	.417	.855	.992	.420	1.238	.342	7.538					
Pan 2	.615	1.820	.907	1.280	.708	.255	.734	.499	6.818	Zone 6-7½				
Pan 3	1.126	.928	1.223	.583	1.687	.478	.639	1.108	7.772	30.830	3.694	63.61	.0582	12.3
Pan 4	.867	.798	1.240	.296	1.615	1.670	.681	1.535	8.702					
Pan 5	1.548	3.690	1.437	2.385	1.730	.815	2.387	.733	14.725	Zone 5-6				
Pan 6	1.816	1.553	3.660	1.333	3.833	2.910	1.930	2.498	19.533	34.258	4.100	34.56	.1186	13.6
Pan 7	2.713	3.760	2047	3.166	3.992	1038	2.595	1.076	20.387	Zone 4-5				
Pan 8	3.310	1.465	3.290	1.693	4.250	3.790	4.790	4.980	27.568	47.955	5.748	28.275	.203	19.1
Pan 9.	2.022	2.340	2.350	2.720	3.445	2.265	2.690	2.750	20.582	Zone 3-4				
Pan 10	2.270	1.780	2.007	1.410	2.250	2.550	5.530	3.960	21.757	42.339	5.070	21.991	.232	16.8
Pan 11	1.837	2.880	3.960	1.485	.992	4.660	3.450	3.493	22.757	Zone 2-3 22.757	2.728	15.708	.1736	9.08
Pan 12	4.025	2.115	1.030	.958	.802	.915	1.055	1.243	12.143	Zone 0-2 12.143	1.454	12.566	.1158	4.84
Totals	23.275	25.277	23.568	18.164	26.296	21.766	27.719	24.217						
Gallons	2.79	3.03	2.823	2.177	3.15	2.61	3.32	2.90			22.794			
PerCent	74.2	80.5	75.2	57.9	83.8	69.3	88.3	77.2			75.8			

TEST NOTES - SET NO. 4.

Side Distribution:- Of the total water discharged by the sprinkler head, 50.13% was thrown outside the rings which were five (5) feet in radius.

25.06% of the total discharge was thrown over the rings two (2) feet from the ceiling.

12.53% was thrown between the rings two (2) feet and four feet five and one half inches (4'-5 1/2"), and

12.53% was thrown under the four foot five and one half inch (4'-5 1/2") ring.

Ceiling Distribution:- The ceiling above the head in a circle three (3) feet in diameter was struck by the spray, heavy drops coming from the circle seven (7) feet in diameter.

Form of Discharge:- Large drops with mist near the outside.

TEST DATA - SET #5.

GRINNELL HEAD UPRIGHT 6" FROM CEILING.
PRESSURE {EFFECTIVE 30.64 #/IN.²
FLOWING #/IN.²}

PLAIN CEILING.
DISCHARGE - 30.1 GAL/MIN.

RUN NUMBER	33	34	35	36	37	38	39	40
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME - MIN. SEC.	11:59	12:00	12:00	12:02	12:00	12:00	11:59	12:00
EFFECTIVE PRESSURE #/IN.²	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64
WT. WATER IN PAN 1. #.OZ.	12:2	19:0	4:14	12:2	12:5	6:10	14:4	5:14
PAN 2.	10:8	19:4	13:3	18:2	13:11	3:7	9:12	6:12
PAN 3.	13:5	12:4	12:8	9:4	28:13	6:8	11:3	14:7
PAN 4.	14:8	9:14	15:11	3:14	17:10	25:3	11:5	18:13
PAN 5.	17:15	39:11	10:9	37:8	29:5	12:7	28:9	21:10
PAN 6.	25:2	22:6	42:0	19:6	55:0	41:9	26:13	32:13
PAN 7.	31:3	48:13	32:10	42:1	50:9	16:1	29:13	21:13
PAN 8.	44:0	25:7	38:13	19:6	43:9	33:4	60:12	64:15
PAN 9.	21:3	25:15	26:13	20:9	22:3	35:9	30:3	37:6
PAN 10.	20:0	25:5	19:10	16:7	13:14	24:7	48:15	31:8
PAN 11.	16:4	22:14	37:12	19:0	16:6	42:8	33:00	30:14
PAN 12.	38:8	21:00	17:13	16:3	16:0	15:6	13:6	20:0

TEST DATA - SET #5.

TIME - 1 MIN. 0 SEC.

RUN NO.	33	34	35	36	37	38	39	40	TOTALS	WEIGHT IN ZONES LBS	GALLONS IN ZONES	AREA OF ZONES FT.^{2}	GAL./SQ.FT. PER MIN. IN ZONES	PER CENT IN ZONES.
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	3.762	3.762	3.762	3.762	3.762	3.762	3.762	3.762	30.10					
WT. WATER IN PAN 1/MIN.	1.010	1.58	.406	1.007	1.026	.552	1.187	.490	7.261					
PAN 2	.877	1.605	1.098	1.507	1.141	.286	.813	.563	7.890	ZONE, 6-7½				
PAN 3	1.110	1.020	1.042	.769	2.385	.542	.932	1.203	9.003	33.897	4.06	63.61	.0638	13.5
PAN 4	1.210	.823	1.307	.322	1.470	2.100	.943	1.568	9.743					
PAN 5	1.497	3.306	.880	3.124	2.442	1.350	2.380	1.802	16.781	ZONE 5-6				
PAN 6	2.093	1.865	3.500	1.612	4.580	3.465	2.233	2.735	22.083	38.864	4.65	34.56	.1347	15.47
PAN 7	2.600	4.070	2.720	3.500	4.220	1.338	2.486	1.820	22.754	ZONE 4-5				
PAN 8	3.670	2.120	3.220	1.612	3.633	2.770	5.070	5.420	27.515	50.269	6.03	28.275	.2133	20.0
PAN 9	1.767	2.163	2.233	1.710	1.850	2.963	2.517	3.112	18.315	ZONE 3-4				
PAN 10	1.835	2.109	1.635	1.370	1.157	2.037	4.076	2.626	16.845	35.160	4.22	21.991	.1917	14.0
PAN 11	1.355	1.907	3.142	1.580	1.364	3.540	2.750	2.515	18.213	ZONE 2-3 18.213	2.18	15.708	.1388	7.25
PAN 12	3.210	1.750	1.483	1.345	1.333	1.281	1.115	1.668	13.185	ZONE 0-2 13.185	1.58	12.566	.1257	5.25
TOTALS	22.234	24.321	22.666	19.458	26.601	22.224	26.502	25.582						
GALLONS	2.663	2.91	2.716	2.33	3.186	2.661	3.174	3.062			22.72			
PER CENT.	70.8	77.3	72.2	62.0	84.7	70.8	84.3	81.4			75.6			

TEST NOTES - SET NO. 5.

Side Distribution:- Of the total water discharged by the sprinkler head, 53.37% was thrown outside the rings which were five (5) feet in radius.

26.69% of the total discharge was thrown over the ring two (2) feet from the ceiling.

15.34% was thrown between the rings two (2) feet and four feet five and one half inches (4'-5 1/2"), and

13.34% was thrown under the four foot five and one half inch (4'-5 1/2") ring.

Ceiling Distribution:- The Ceiling above the head in a four (4) foot diameter circle was struck by the spray, heavy drops coming from the circle eight (8) feet in diameter.

Form of Discharge:- Small drops with heavy mist.

TEST DATA - SET #6.

GRINNELL HEAD UPRIGHT 10" FROM CEILING.
PRESSURE {EFFECTIVE-30.75#/IN.²
FLOWING #/IN.²}

PLAIN CEILING.
DISCHARGE-30.2 GAL/MIN

RUN NUMBER	41	42	43	44	45	46	47	48
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME.- MIN. SEC.	11:59	11:59	12:01	12:00	12:00	12:07	12:00	12:00
EFFECTIVE PRESSURE #/in.²	30.75	30.75	30.75	30.75	30.75	30.75	30.75	30.75
WT. WATER IN PAN 1. #-.OZ.	12:12	20:6.	5:9	14:8	19:4	7:6	12:14	6:12
PAN 2.	10:5	18:7	14:3	18:3	13:0	3:1	9:2	7:2
PAN 3.	12:0	9:12	11:9	11:0	20:14	6:2	13:0	12:7
PAN 4.	15:11	9:2	12:11	3:14	22:4	27:8	16:3	16:5
PAN 5.	16:1	45:11	21:11	37:3	27:6	13:4	28:14	13:9
PAN 6.	22:4	16:6	40:6	20:14	44:10	40:5	33:7	34:9
PAN 7.	23:8	47:15	36:3	37:4	39:7	22:5	34:3	29:1
PAN 8.	36:9	19:4	42:3	17:11	35:1	25:1	71:5	58:14
PAN 9.	12:15	21:8	22:11	15:0	22:10	36:14	32:7	28:15
PAN 10.	13:15	19:3	19:14	17:13	11:11	21:1	28:2	23:3
PAN 11.	15:10	19:8	23:0	20:14	18:14	34:3	32:4	23:8
PAN 12.	41:6	19:12	16:10	16:2	16:2	14:6	16:14	17:2

TEST DATA - SET #6.

TIME - 1 MIN. 0 SEC.

RUN NO.	41	42	43	44	45	46	47	48	TOTALS	WEIGHT IN ZONES LBS.	GALLONS IN ZONES	AREA OF ZONES FT.^{2}	GAL./SQ. FT. PER MIN. IN ZONES	PER CENT IN ZONES
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	3.775	3.775	3.775	3.775	3.775	3.775	3.775	3.775	30.2					
WT. WATER IN PAN 1/MIN.	1.063	1.700	.463	1.208	1.603	.609	1.072	.563	8.281					
PAN 2.	.860	1.537	1.180	1.515	1.082	.248	.758	.592	7.772	ZONE, 6-7½				
PAN 3.	1.001	.812	.963	.917	1.740	.505	1.083	1.036	8.057	34.386	4.12	63.61	.0649	13.6
PAN 4.	1.308	.760	1.055	.323	1.852	2.270	1.348	1.360	10.276					
PAN 5	1.338	3.804	1.805	3.098	2.280	1.095	2.410	1.130	16.960	ZONE 5-6				
PAN 6	1.853	1.365	3.360	1.739	3.720	3.330	2.786	2.880	21.033	37.993	4.55	34.56	.131	15.0
PAN 7	1.960	4.000	3.010	3.103	3.284	1.843	2.850	2.420	22.470	ZONE 4-5				
PAN 8	3.047	1.605	3.512	1.473	2.916	2.068	5.940	4.915	25.476	47.946	5.73	28.275	.202	19.0
PAN 9	1.078	1.792	1.888	1.250	1.883	3.049	2.700	2.410	16.050	ZONE 3-4				
PAN 10	1.160	1.599	1.655	1.483	.974	.740	2.342	1.932	12.885	28.935	3.46	21.991	.171	11.5
PAN 11	1.303	1.627	1.915	1.738	1.573	2.824	2.690	1.958	15.628	ZONE 2-3 15.628	1.87	15.708	.119	6.19
PAN 12	3.450	1.645	1.383	1.342	1.343	1.187	1.406	1.426	13.182	ZONE 0-2 13.182	1.58	12.566	.126	5.23
TOTALS	19.421	22.246	22.189	19.189	24.250	20.768	27.385	22.622						
GALLONS	2.33	2.66	2.65	2.30	2.91	2.49	3.28	2.71			21.24			
PER CENT	61.7	70.5	70.3	60.9	77.1	66.0	86.8	71.8			70.4			

TEST NOTES - SET No. 6.

Side Distribution:- Of the total water discharged by the sprinkler head, 58.2% was thrown outside the rings which were five (5) feet in radius.

36.3% of the total discharge was thrown one the ring two (2) feet from the ceiling.

7.27% was thrown between the rings two (2) feet and four feet five and one half inches (4' 5 1/2"), and

14.5% was thrown under the four foot five and one half inch (4' 5 1/2") ring.

Ceiling Distribution;- Ceiling above the head in a five (5) foot diameter circle was struck by the spray, heavy drops coming from the edge of the ceiling.

Form of Discharge;- Heavy mist but slightly less than in Sets No. 4 and No. 5.

TEST DATA - SET #7.

GRINNELL HEAD UPRIGHT 3" FROM CEILING.
PRESSURE - {EFFECTIVE 91.6 #/IN.^{2} / FLOWING #/IN.^{2}}

PLAIN CEILING.
DISCHARGE - 52.75 GAL/MIN

RUN NUMBER	49	50	51	52	53	54	55	56
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME - MIN. SEC.	9:00	8:01	$8:02\frac{3}{5}$	$8:02\frac{3}{5}$	$8:01\frac{2}{5}$	8:00	6:59	8:02
EFFECTIVE PRESSURE #/IN.^{2}	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6
WT. WATER IN PAN 1 #.OZ.	30:4	42:12	1:6	26:6	25:7	3:4	3:0	5:1
PAN 2	21:0	39:12	6:2	25:1	17:6	1:8	4:4	11:11
PAN 3	32:0	48:2	15:7	14:2	31:6	10:6	20:3	21:2
PAN 4	12:2	22:1	22:7	2:15	23:6	36:1	13:8	14:3
PAN 5	37:8	86:1	10:7	45:3	37:14	6:11	15:7	29:6
PAN 6	32:10	42:6	53:0	21:10	29:5	30:2	41:0	64:4
PAN 7	22:13	54:11	20:15	28:5	26:4	21:3	42:13	45:9
PAN 8	40:2	33:15	46:6	20:3	16:11	26:8	35:5	56:3
PAN 9	19:5	31:4	29:12	16:3	4:3	64:3	62:14	37:6
PAN 10	33:2	33:1	29:7	17:13	8:13	14:5	14:4	32:5
PAN 11	22:11	31:10	49:14	21:10	8:10	21:14	21:9	23:4
PAN 12	48:4	20:15	18:4	12:12	7:4	9:6	11:10	19:00

TEST DATA - SET # 7.

TIME.-1 MIN. 0 SEC.

RUN NO.	49	50	51	52	53	54	55	56	TOTALS	WEIGHT IN ZONES LBS.	GALLONS IN ZONES	AREA OF ZONES FT.^{2}	GAL/SQ.FT. PER MIN. IN ZONES	PER CENT IN ZONES
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	6.594	6.594	6.594	6.594	6.594	6.594	6.594	6.594	52.75					
WT. WATER IN PAN 1/MIN.	3.36	5.34	.17	3.28	3.17	.41	.43	.62	16.78					
PAN 2	2.33	4.96	.76	3.12	2.16	.19	.61	1.45	16.58	ZONE 6-7½				
PAN 3	3.56	6.01	1.92	1.76	3.91	1.30	2.89	2.62	23.97	75.715	9.08	63.61	.143	17.2
PAN 4	1.35	2.76	2.79	.365	2.91	4.52	1.93	1.76	18.385					
PAN 5	4.17	10.73	1.32	5.61	4.72	.86	2.21	3.65	33.27	ZONE 5-6				
PAN 6	3.63	5.28	6.59	2.69	3.66	3.77	5.87	8.00	39.49	72.76	8.72	34.56	.252	16.5
PAN 7	2.54	6.82	2.60	3.52	3.27	2.65	6.13	5.66	33.19	ZONE 4-5				
PAN 8	4.46	4.24	5.76	2.51	2.08	3.31	5.05	6.99	34.40	67.59	8.10	28.275	.286	15.4
PAN 9	2.15	3.90	3.70	2.01	.52	8.03	9.00	4.65	33.86	ZONE 3-4				
PAN 10	3.68	4.13	3.67	2.22	1.10	1.79	2.04	4.02	22.65	56.51	6.77	21.991	.308	12.8
PAN 11	2.52	3.95	6.20	2.69	1.07	2.74	3.08	2.90	25.15	ZONE 2-3 25.15	3.01	15.708	.191	5.71
PAN 12	5.36	2.62	2.27	1.59	.90	1.17	1.67	2.36	17.94	ZONE 0-2 17.94	2.15	12.566	.171	4.08
TOTALS	39.11	60.74	37.75	31.365	29.47	30.74	40.91	44.68						
GALLONS	4.48	7.28	4.52	3.76	3.53	3.68	4.90	5.35			37.83			
PER CENT	68.1	100.6	68.6	57.1	53.6	55.9	74.4	81.2			71.7			

TEST NOTES - SET NO. 7.

Side Distribution:- Of the total water discharged by the sprinkler head, 62.0% was thrown outside the rings which were five (5) feet in radius.

38.7% of the total discharge was thrown over the ring two (2) feet from the ceiling,

15.5% was thrown between rings two (2) feet and four feet five and one half inches (4'-5 1/2"), and

7.75% was thrown under the four foot five and one half inch (4'-5 1/2") ring.

Ceiling Distribution:- Ceiling above the head in a three (3) foot diameter circle was struck by the spray, heavy drops coming from the circle eight (8) feet in diameter.

Form of Discharge:- Very heavy mist.

TEST DATA - SET #8

GRINNELL HEAD UPRIGHT 6" FROM CEILING
PRESSURE - {EFFECTIVE 91.6 #/IN.² / FLOWING #/IN.²}

PLAIN CEILING
AVERAGE TIME 8 MIN - 30 SEC.
DISCHARGE - 52.75 GAL./MIN.

RUN NUMBER	57	58	59	60	61	62	63	64
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME. MIN. - SEC.	8:02 $\frac{2}{5}$	8:01 $\frac{1}{5}$	8:01 $\frac{3}{5}$	8:19	8:05	8:02	8:03	8:02
EFFECTIVE PRESSURE. #/IN.²	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6
WT. WATER IN PAN 1. # OZ.	21:14	41:1	2:5	31:14	22:8	2:7	6:5	4:10
PAN 2	16:3	54:4	7:12	26:6	23:10	2:7	3:9	11:11
PAN 3	28:7	31:6	22:5	15:4	32:12	16:11	17:0	19:13
PAN 4	12:6	19:5	48:10	3:4	18:14	40:3	11:15	18:13
PAN 5	34:7	87:13	16:3	38:15	32:7	9:1	27:4	33:2
PAN 6	32:4	45:10	70:15	23:13	20:14	34:10	51:15	77:4
PAN 7	33:9	54:5	29:14	18:9	18:1	35:11	59:1	46:12
PAN 8	13:14	36:7	41:4	23:3	13:4	22:9	46:1	69:13
PAN 9	22:15	27:15	33:4	14:3	4:3	68:8	55:11	31:3
PAN 10	32:3	31:11	21:11	20:0	8:5	9:6	14:9	39:7
PAN 11	31:9	32:4	50:6	21:11	8:8	16:12	21:8	24:0
PAN 12	44:0	32:13	25:7	14:2	9:6	8:6	13:3	18:11

TEST DATA - SET #8.

TIME - 1 MIN. 0 SEC.

RUN NO.	57	58	59	60	61	62	63	64	TOTALS	WEIGHT IN ZONES LBS.	GALLONS IN ZONES	AREA OF ZONES FT.^{2}	GAL/SQ.FT. PER MIN IN ZONES	PER CENT IN ZONES.
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	6.594	6.594	6.594	6.594	6.594	6.594	6.594	6.594	52.75					
WT. WATER IN PAN 1/MIN	2.72	5.13	.29	3.84	2.78	.303	.785	.576	16.424					
PAN 2	2.01	6.77	.97	3.17	2.93	.303	.443	1.454	18.050	ZONE 6-7½				
PAN 3	3.54	3.91	2.78	1.83	4.05	2.075	2.112	2.470	22.767	78.80	9.35	63.61	.147	17.7
PAN 4	1.54	2.41	6.06	.39	2.33	5.000	1.483	2.346	21.559					
PAN 5	4.28	10.94	2.02	4.68	4.02	1.129	3.386	4.127	34.582	ZONE 5-6				
PAN 6	4.02	5.70	8.83	2.86	2.58	4.320	6.450	9.625	44.385	78.967	9.55	34.56	.277	18.1
PAN 7	4.17	6.77	3.72	2.23	2.24	4.441	7.350	5.824	36.745	ZONE 4-5				
PAN 8	1.73	4.55	5.14	2.78	1.64	2.806	5.730	8.700	33.076	69.821	8.37	28.275	.296	15.9
PAN 9	2.85	3.48	4.15	1.70	1.52	8.53	6.85	3.88	31.960	ZONE 3-4				
PAN 10	4.00	3.95	2.70	2.40	1.03	1.167	1.816	4.915	21.978	53.938	6.46	21.991	.294	12.3
PAN 11	3.92	4.02	6.28	2.61	1.05	2.086	2.671	2.99	25.627	ZONE 2-3 25.627	3.07	15.708	.195	5.82
PAN 12	5.47	4.10	3.17	1.70	1.16	1.043	1.637	2.327	20.607	ZONE 0-2 20.607	2.47	12.566	.197	4.70
TOTALS	40.25	61.73	46.11	30.19	26.33	33.203	40.713	49.234						
GALLONS	4.823	7.400	5.53	3.62	3.15	3.98	4.875	5.90			39.27			
PER CENT	73.2	112.2	84.0	55.0	47.8	60.5	74.0	89.6			74.5			

TEST NOTES - SET NO. 8.

Side Distribution:- Of the total water discharged by the sprinkler head, 61.3% was thrown outside the rings which were five (5) feet in radius.

40.8% of the total discharge was thrown over the ring two (2) feet from the ceiling,

13.6% was thrown between the rings two (2) feet and four feet five and one half inches (4' 5 1/2"), and

6.8% was thrown under the four foot five and one half inch (4'- 5 1/2") ring.

Ceiling Distribution:- Ceiling above the head was struck by the spray in streaks out to the circle seven (7) feet in diameter, heavy drops coming from the edge of the ceiling.

Form of Discharge:- Heavy mist.

TEST DATA - SET #9.

GRINNELL HEAD UPRIGHT 10" FROM CEILING.
PRESSURE- {EFFECTIVE 91.6 #/IN.^{2} / FLOWING #/IN.^{2}}

PLAIN CEILING.
DISCHARGE -52.75 GAL/MIN.

RUN NUMBER	65	66	67	68	69	70	71	72
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII
TIME. - MIN.-SEC.	8:03	7:58	7:58	8:00	8:01	6:57	6:59	7:59
EFFECTIVE PRESSURE #/IN.^{2}	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6
WT. WATER PAN 1 #OZ.	16:14	46:4	2:2	35:2	14:4	3:11	26:4	4:0
PAN 2	16:6	54:8	7:1	23:12	26:8	4:10	12:10	11:6
PAN 3	20:6	26:10	15:15	10:12	30:4	26:00	25:11	30:00
PAN 4	6:12	14:5	28:13	1:00	17:00	23:8	13:1	39:3
PAN 5	26:9	79:15	15:14	26:6	23:11	14:12	60:9	27:7
PAN 6	27:2	34:15	58:0	12:2	22:13	22:8	42:14	88:0
PAN 7	24:15	52:9	22:13	9:11	16:11	36:4	61:7	34:4
PAN 8	30:3	27:14	44:3	9:14	15:13	9:8	22:3	51:00
PAN 9	17:1	30:12	20:15	8:13	7:8	46:5	21:5	21:7
PAN 10	18:11	21:3	21:11	11:2	11:5	8:2	10:11	23:6
PAN 11	25:7	33:1	34:0	16:9	15:4	16:00	14:12	21:6
PAN 12	48:12	36:13	25:3	14:6	14:15	8:6	11:12	19:12

TEST DATA. - SET #9. TIME. - 1 MIN. 0 SEC.

RUN NO.	65	66	67	68	69	70	71	72	TOTALS	WEIGHTS IN ZONES LBS	GALLONS IN ZONES	AREA OF ZONES FT.^{2}	GAL./SQ.FT. PER MIN. IN ZONES	PERCENT IN ZONES
POSITION OF PANS	I	II	III	IV	V	VI	VII	VIII						
TOTAL DISCHARGE	6.594	6.594	6.594	6.594	6.594	6.594	6.594	6.594	52.75					
WT. WATER IN PAN 1/MIN	2.09	5.81	.27	4.39	1.78	.53	3.76	.50	19.13					
PAN 2	2.03	6.83	.89	2.97	3.30	.67	1.81	1.43	19.93	ZONE 6-7½				
PAN 3	2.53	3.34	2.00	1.34	3.78	3.74	3.68	3.76	24.17	81.90	9.81	63.61	.154	18.6
PAN 4	.84	1.80	3.62	.13	2.12	3.38	1.87	4.91	18.67					
PAN 5	3.30	10.01	1.99	3.29	2.95	2.12	8.68	3.44	35.79	ZONE 5-6				
PAN 6	3.37	4.39	7.28	1.51	2.85	3.24	6.14	11.00	39.78	75.57	9.05	34.56	.262	17.2
PAN 7	3.09	6.60	2.87	1.21	2.08	5.07	8.79	4.29	34.00	ZONE 4-5				
PAN 8	3.75	3.50	5.54	1.23	1.97	1.37	3.18	6.39	26.93	60.93	7.29	28.275	.258	13.8
PAN 9	2.12	5.11	2.63	1.10	.94	6.66	3.05	2.69	24.30	ZONE 3-4				
PAN 10	2.32	2.66	2.72	1.39	1.41	1.17	1.53	3.92	17.12	41.42	4.96	21.991	.226	9.42
PAN 11	3.16	4.15	4.27	2.07	1.90	2.30	2.11	3.67	23.63	ZONE 2-3 23.63	2.83	15.708	.180	5.37
PAN 12	6.05	4.65	3.16	1.80	1.86	1.20	1.69	2.48	22.89	ZONE 0-2 22.89	2.74	12.566	.218	5.20
TOTALS	34.65	58.86	37.14	22.43	26.94	31.45	46.29	48.48						
GALLONS	4.15	7.04	4.44	2.69	3.23	3.77	5.55	5.80			36.68			
PERCENT	63.0	106.8	67.4	40.8	49.0	57.2	84.3	88.0			69.6			

TEST NOTES - SET NO. 9.

Side Distribution:- Of the total water discharged by the sprinkler head, 66.2% was thrown outside the rings which were five feet in radius.

44.2% of the total discharge was thrown over the ring two (2) feet from the ceiling.

14.7% was thrown between the rings two (2) feet and four feet five and one half inches (4'-5 1/2 "), and

7. 35% was thrown under the four foot five and one inch (4'-5 1/2") ring.

Ceiling Distribution:- The spray follows the notches in the deflector and strikes in a circle five (5) feet in diameter, heavy drops coming from the edge of the ceiling.

Form of Discharge:- Heavy mist.

PART III. THE CONCLUSIONS.

CHAPTER I.

CONCLUSIONS ON DESIGN OF APPARATUS

An important factor of a good testing apparatus is a good flexible water supply, which will deliver water without pulsation at as high a pressure as is needed or about 150 pounds per square inch with a suction lift of about ten feet. The best type of pump for this purpose is a multi-stage centrifugal pump, driven by an electric motor directly connected to the pump. The capacity of the pump at 150 pounds should be at least 100 gallons per minute. The pressure adjustment is best accomplished by a gate valve in the discharge piping near the pump and a small by-pass around the gate controlled by a globe valve. In order to adjust the system to a certain pressure, the gate valve is open until the gauge shows a pressure just below that desired, then the globe valve in the by-pass around the gate is opened, and adjusted until the correct pressure is reached. The by-pass should be small so that a fine adjustment is possible. The gauges should be piped from the piezometer to a point near the valve so that the adjustment can be made while watching the gauges.

The apparatus for floor distribution proved very satisfactory, giving the desired results, namely distribution in zones around the center, or point directly under the head.

By combining results on floor distribution with estimates on side and ceiling distribution, the value of the head can be easily estimated, by comparing it with standard specifications made up from results of tests with a number of heads and also taking into consideration the important factors connected with distribution. As the object of this investigation

was only to determine a method by which this standard could be determined and sprinklers tested in the future, and as time would not permit further tests, no comparison was made. The application of the method, however, was carried out and a complete set of tests was made with one head. The tests were made with a Grinnell Head. (Stationary Deflector, see illustration on next page.)

CHAPTER II.

CONCLUSIONS DERIVED FROM TESTS

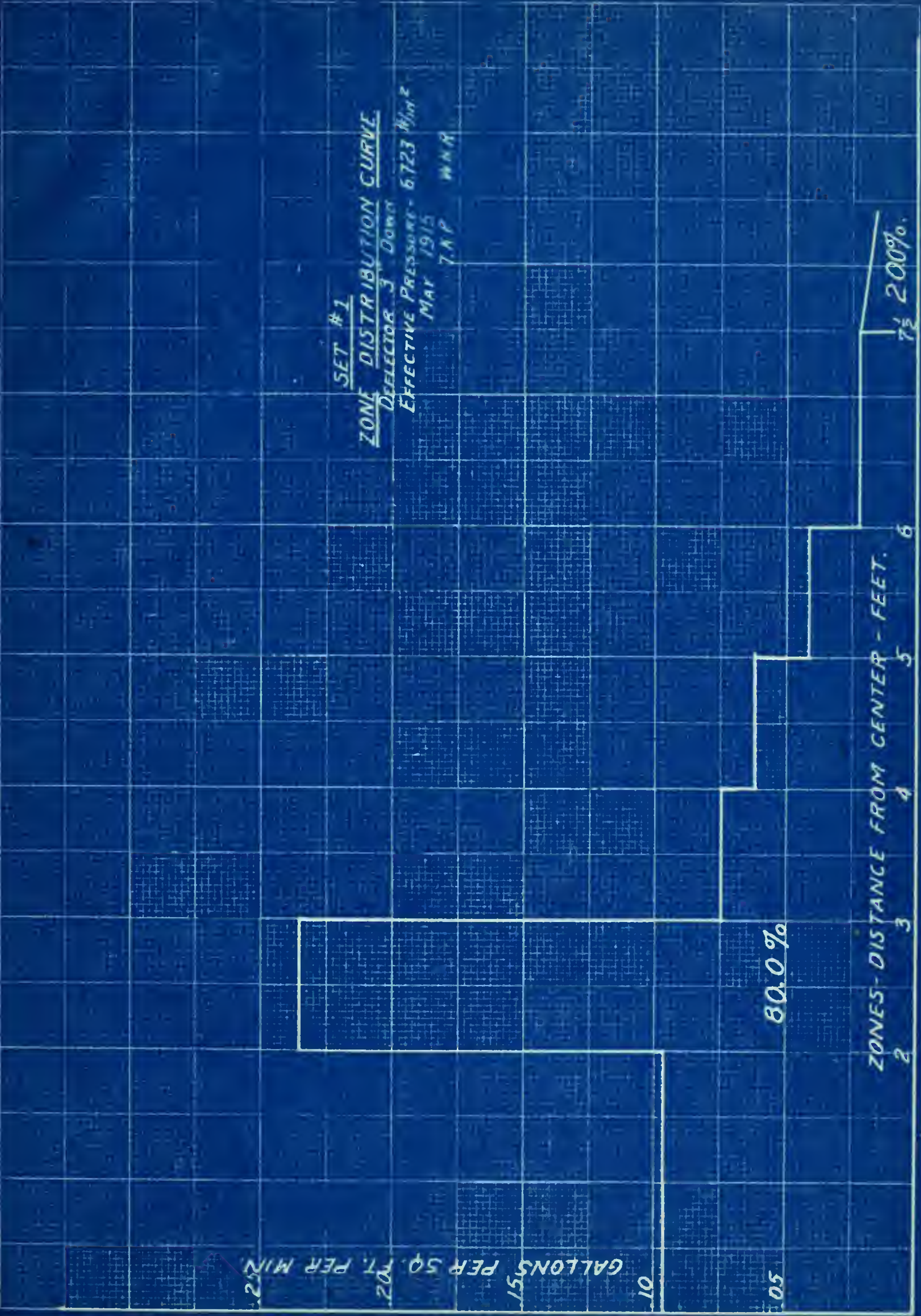
The tests show that the apparatus is practical, and the time necessary to make runs is reasonable. The five pound tests taking on an average about 35 minutes for a complete run, the 25 pound tests 30 minutes, and the 90 only 20 minutes.

From a careful examination of the results, curves, diagrams, and notes obtained with the Grinnell head it is possible to state, that as the head is lowered, increasing the distance between the ceiling and deflector, the distribution to the outer zones is increased, giving a better general distribution over both floor and ceiling. This is desirable up to the point where the percentage of water thrown outside of the seven and a half (7 1/2) foot circle is excessive. The best distance shown in the tests, which combines both of these features is six (6) inches.

The sector diagrams show that at high pressures the general form of the diagram changes. This is probably due to the fact that a larger percentage of the water at high pressures does not pass through the notches of the deflector.

CHAPTER III.

DISTRIBUTION DIAGRAMS:-



SET #1

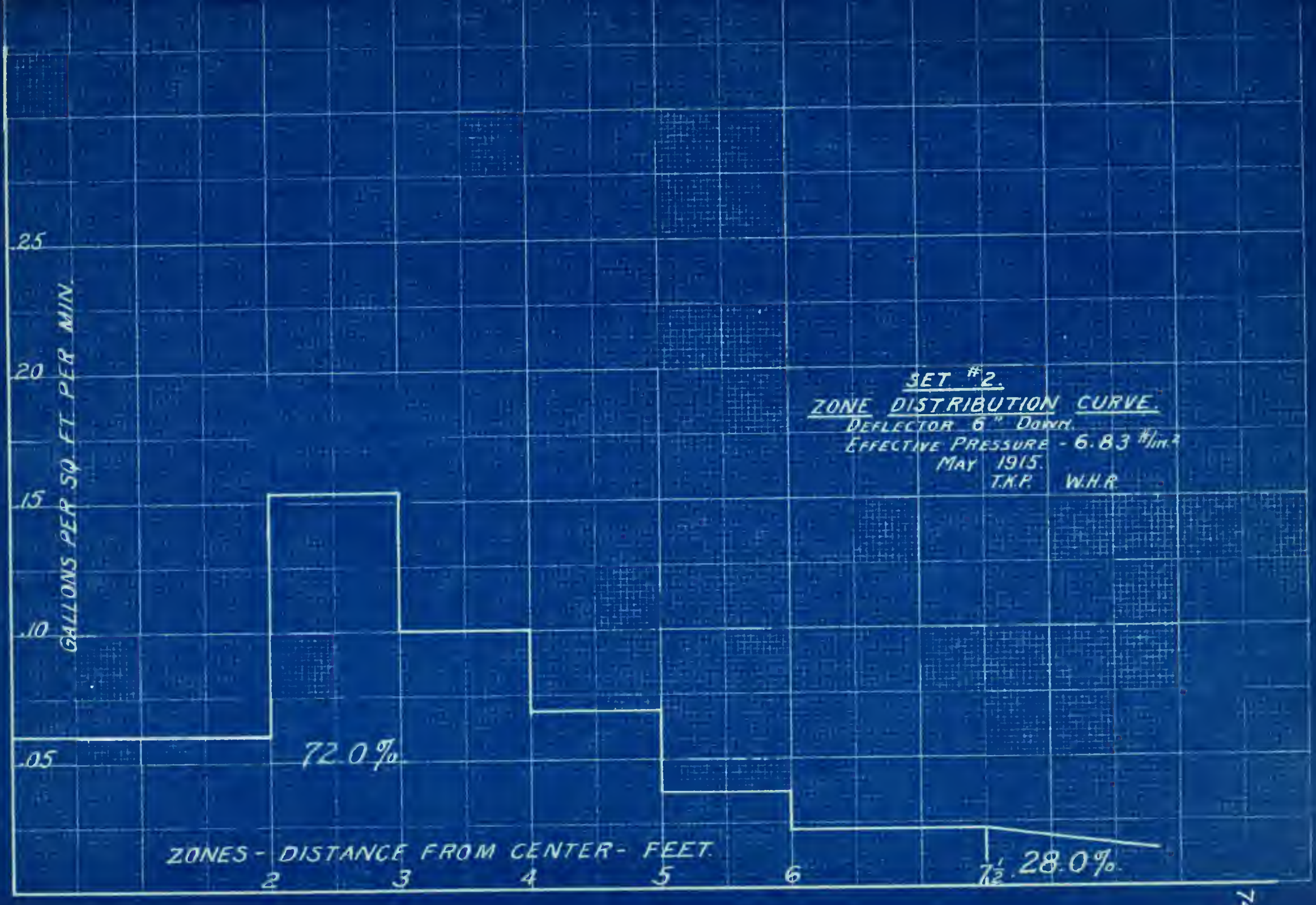
ZONE DISTRIBUTION CURVE

DEFLECTOR 3" DOWN

EFFECTIVE PRESSURE - 6.723 #/in²

MAY 1915

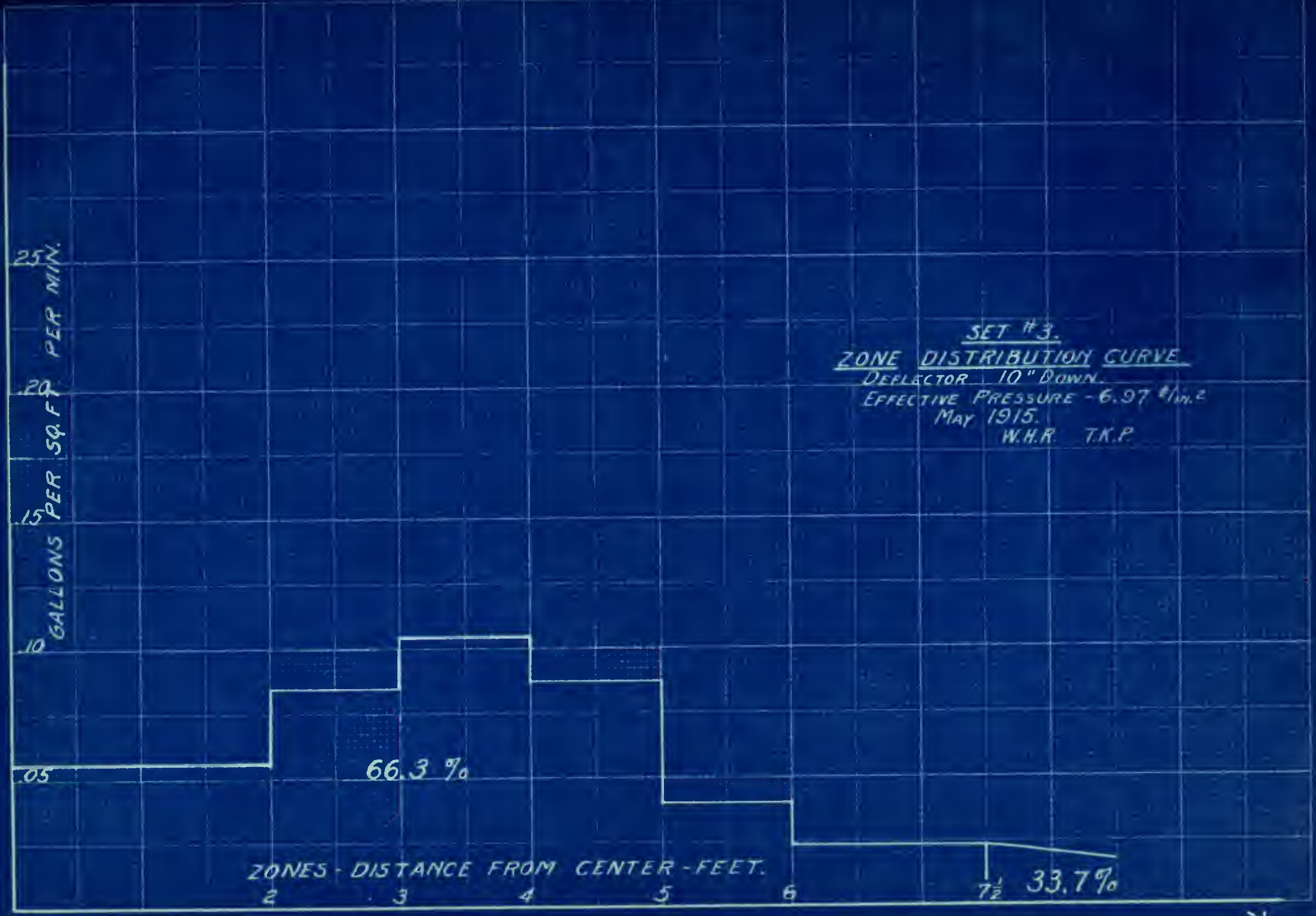
T.A.P. W.H.R.



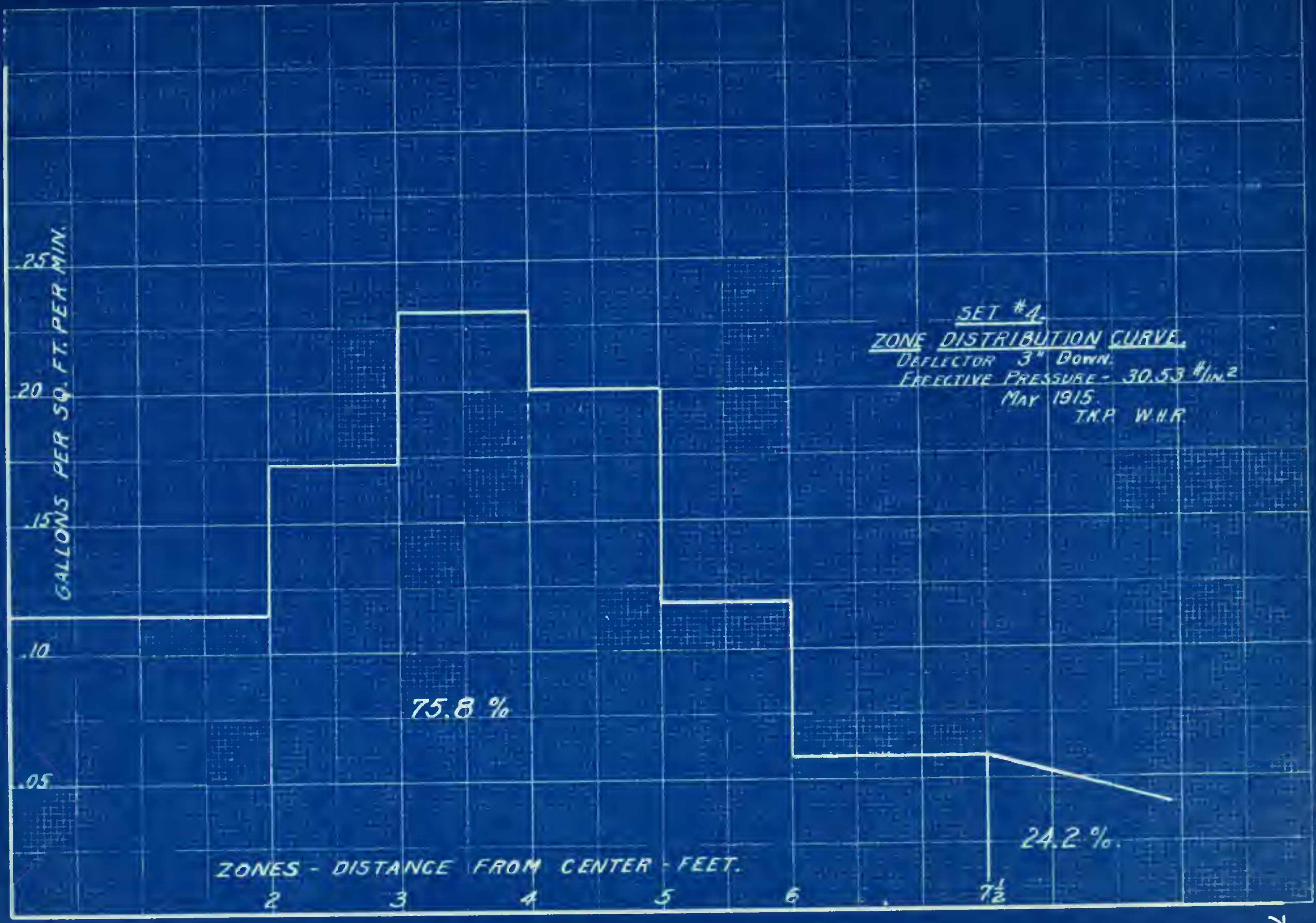
SET #2.

ZONE DISTRIBUTION CURVE.

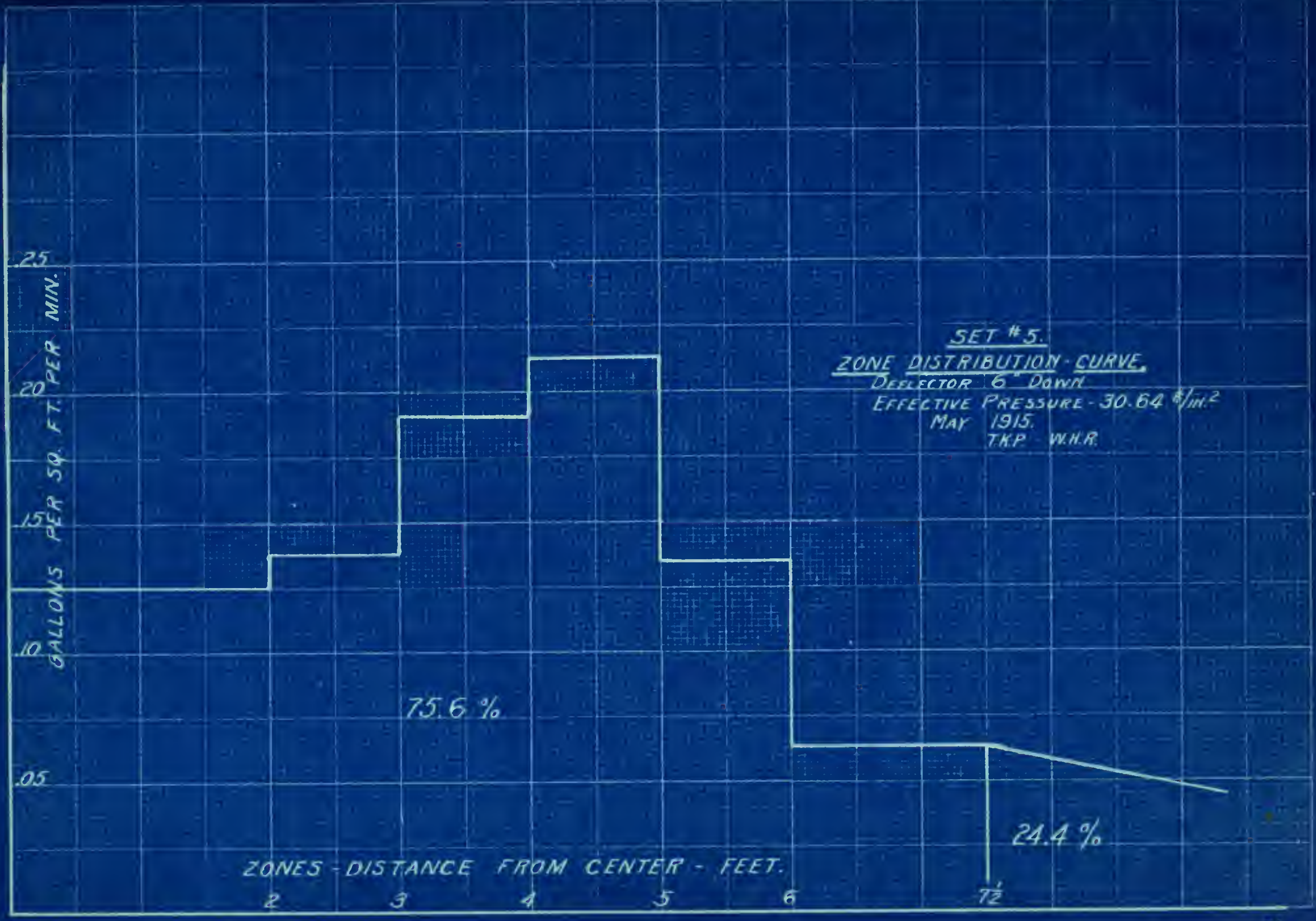
DEFLECTOR 6" DOWN.
EFFECTIVE PRESSURE - 6.83 #/in.²
MAY 1915.
T.K.P. W.H.R.

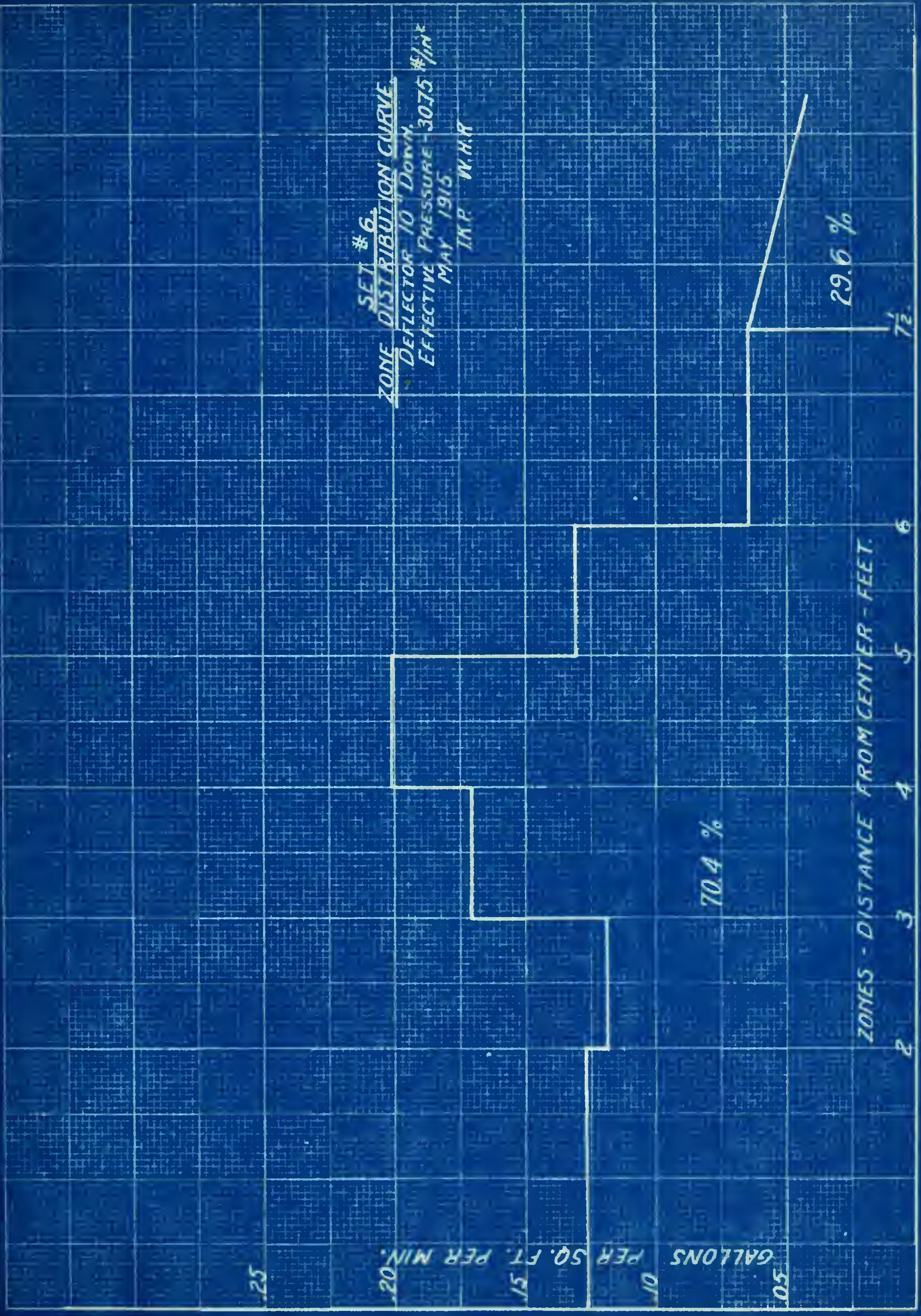


SET #3.
ZONE DISTRIBUTION CURVE.
DEFLECTOR 10" DOWN.
EFFECTIVE PRESSURE - 6.97 #/in.²
MAY 1915.
W.H.R. T.K.P.

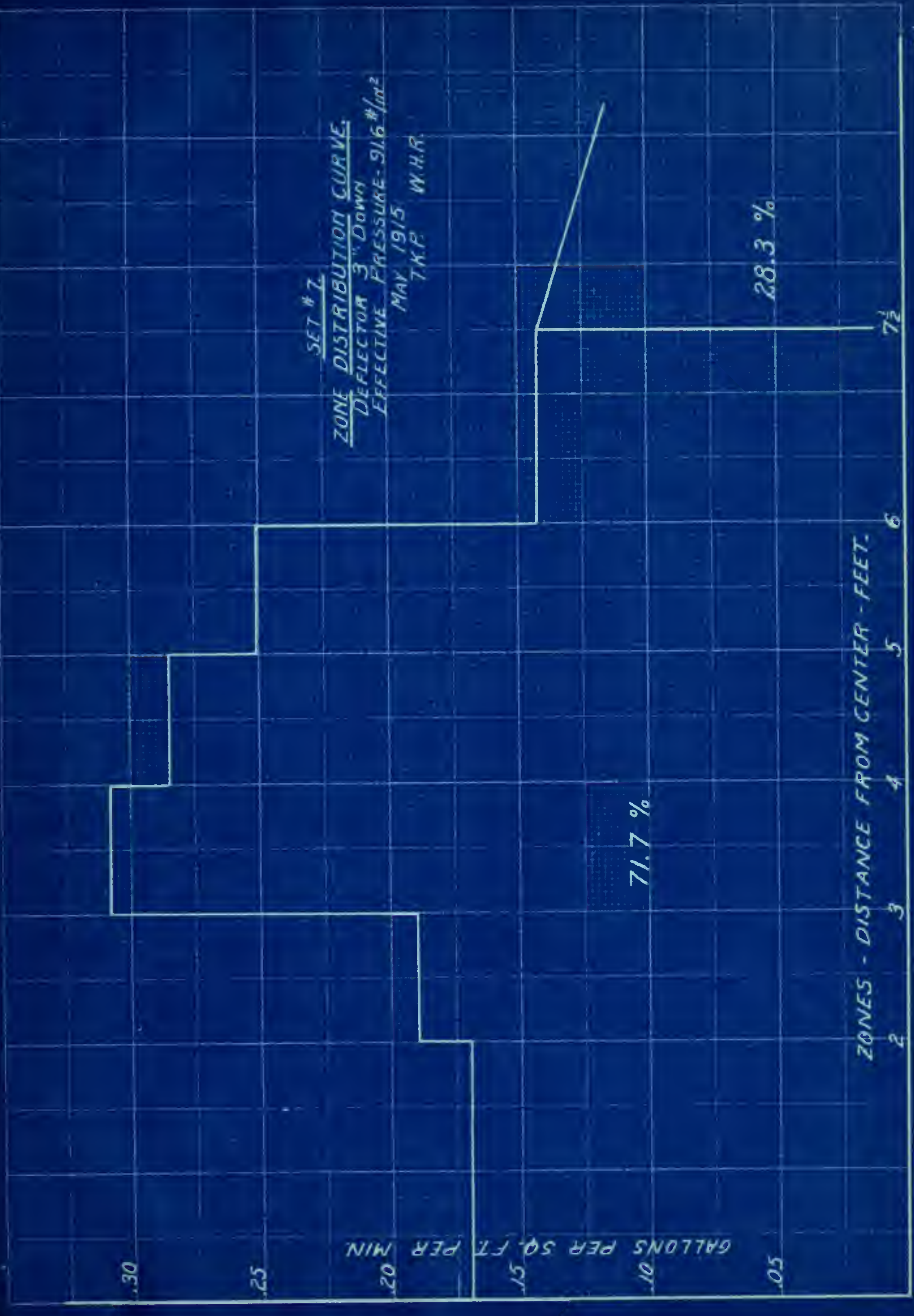


SET #4.
ZONE DISTRIBUTION CURVE.
DEFLECTOR 3" DOWN.
EFFECTIVE PRESSURE - 30.53 #/IN.²
MAY 1915.
T.K.P. W.H.R.

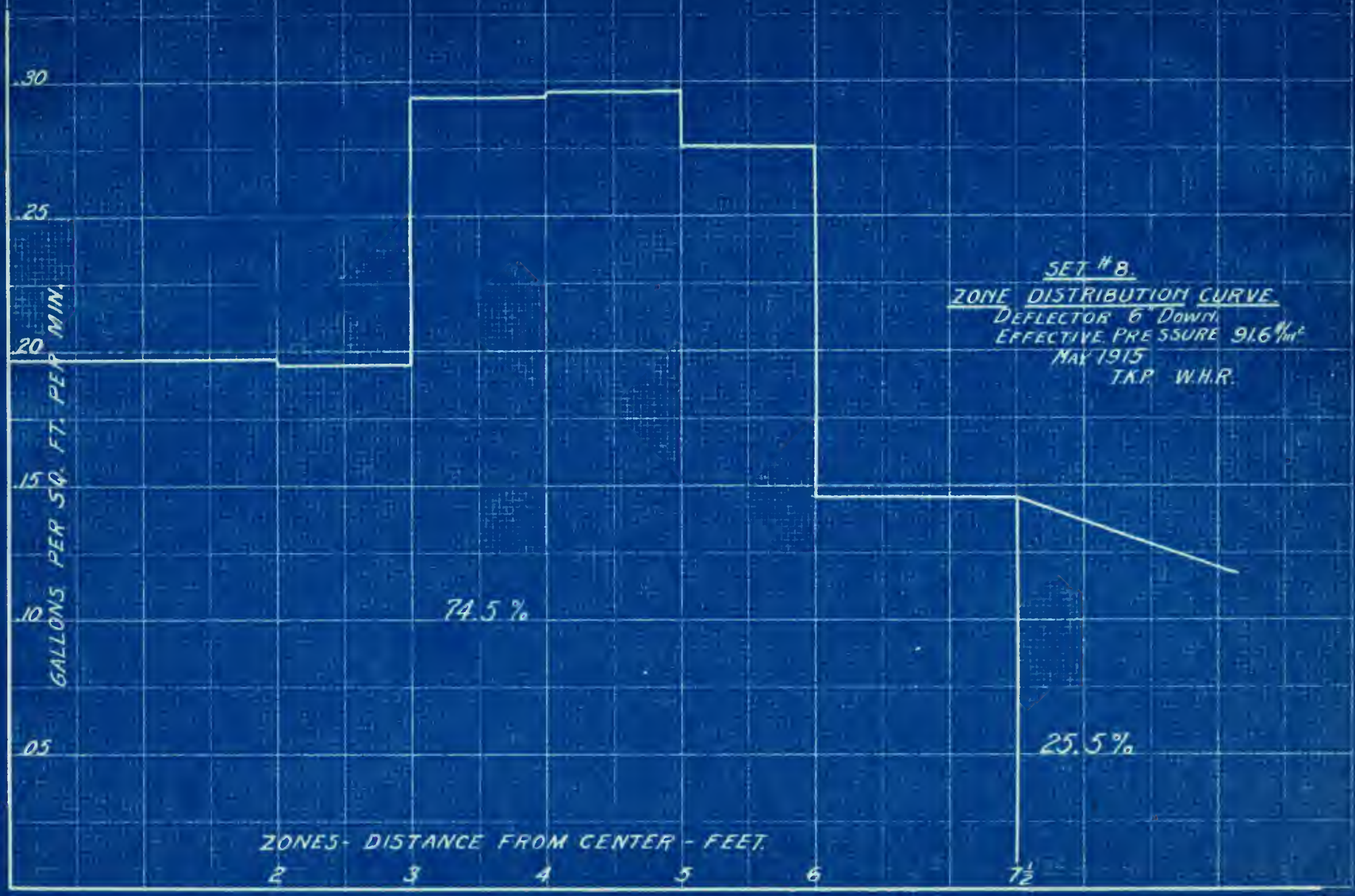

SET #5.
ZONE DISTRIBUTION - CURVE.
DEFLECTOR 6" DOWN
EFFECTIVE PRESSURE - 30.64 #/IN.²
MAY 1915.
T.K.P. W.H.R.
GALLONS PER SQ. FT. PER MIN.
.25
.20
.15
.10
.05
75.6 %
24.4 %
ZONES - DISTANCE FROM CENTER - FEET.
2
3
4
5
6
7½



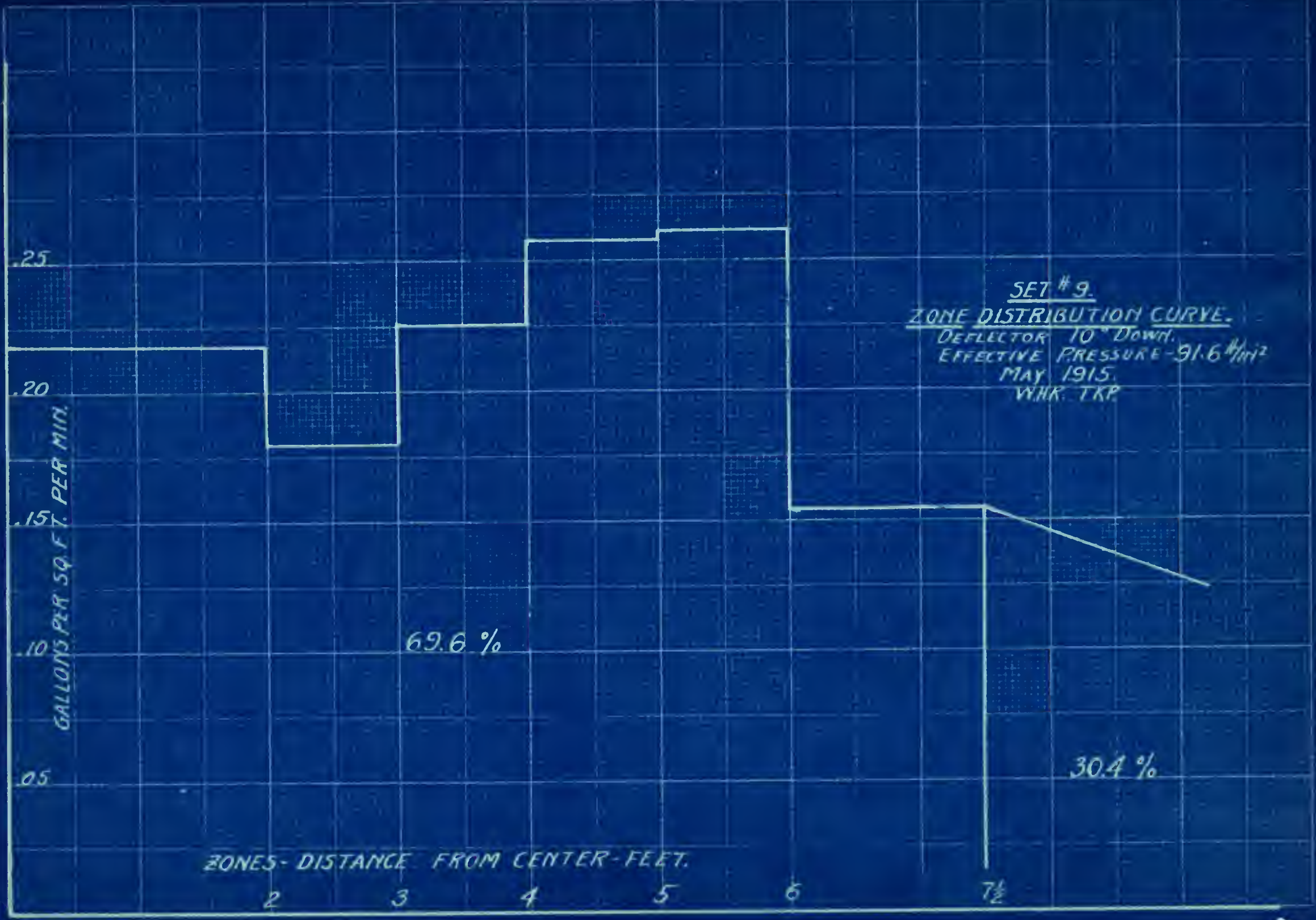
SET #6.
ZONE DISTRIBUTION CURVE.
DEFLECTOR 10" DOWN.
EFFECTIVE PRESSURE 30.75 #/in.
MAY 1915.
I.K.P. W.H.R.



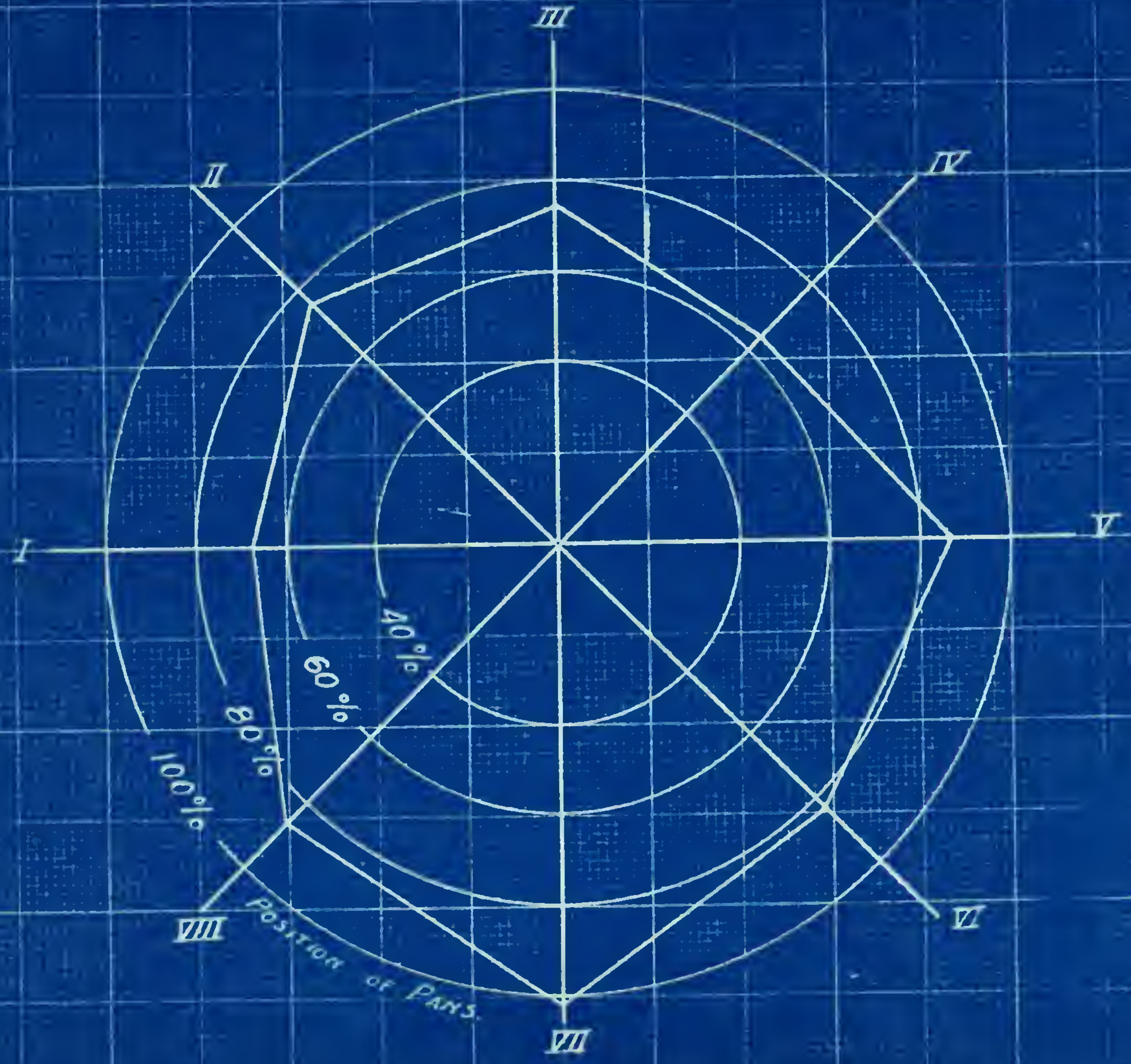
SET #7.
ZONE DISTRIBUTION CURVE.
DEFLECTOR 3" DOWN
EFFECTIVE PRESSURE - 91.6 #/in²
MAY 1915
T.K.P. W.H.R.



SET #8.
ZONE DISTRIBUTION CURVE.
DEFLECTOR 6" DOWN.
EFFECTIVE PRESSURE 91.6#/in²
MAY 1915
T.K.P. W.H.R.



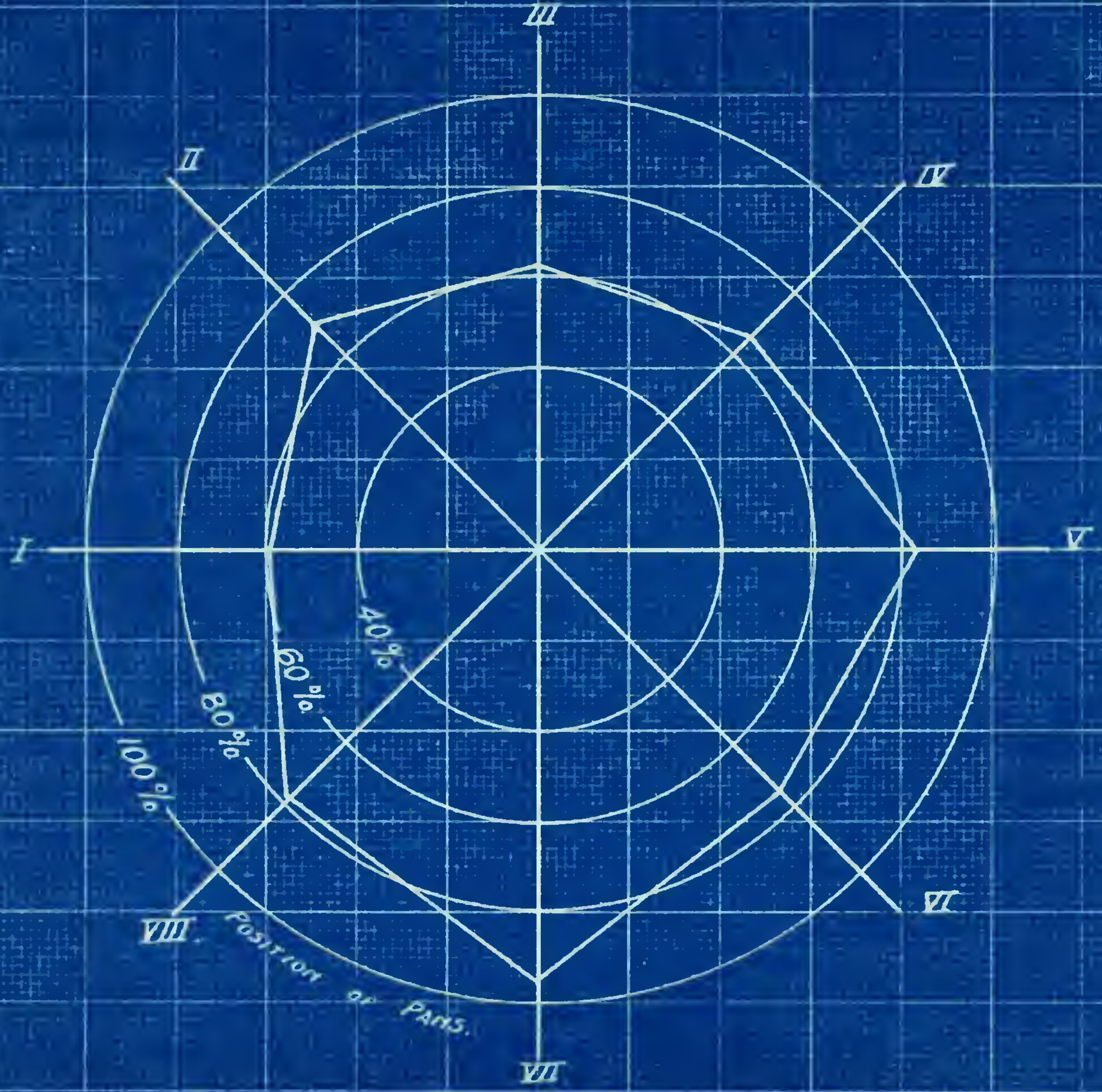
SET #9.
ZONE DISTRIBUTION CURVE.
DEFLECTOR 10" DOWN.
EFFECTIVE PRESSURE-91.6 #/in²
MAY 1915.
W.H.R. T.K.P.



SET #1.

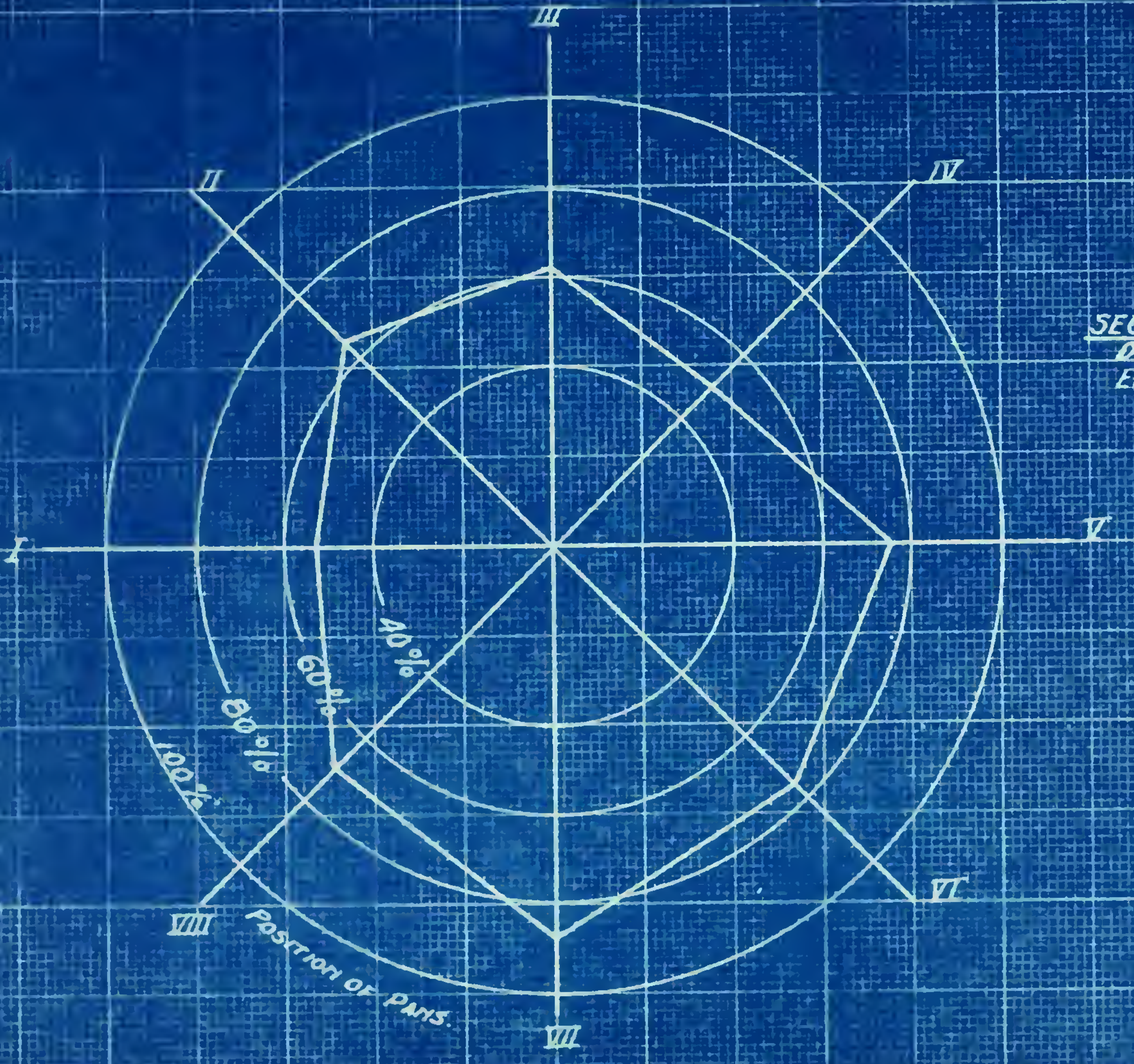
SECTOR DISTRIBUTION CURVE.

Deflector 3" Down
Pressure (Effective): 6.723 #/in^2
May 1915
TKP WHR



SET # 2
SECTOR DISTRIBUTION CURVE

Deflector 6" Down.
Effective Pressure - 6.83 $\#/in^2$
May 1915.
W.H.R T.K.P.



SET # 3.

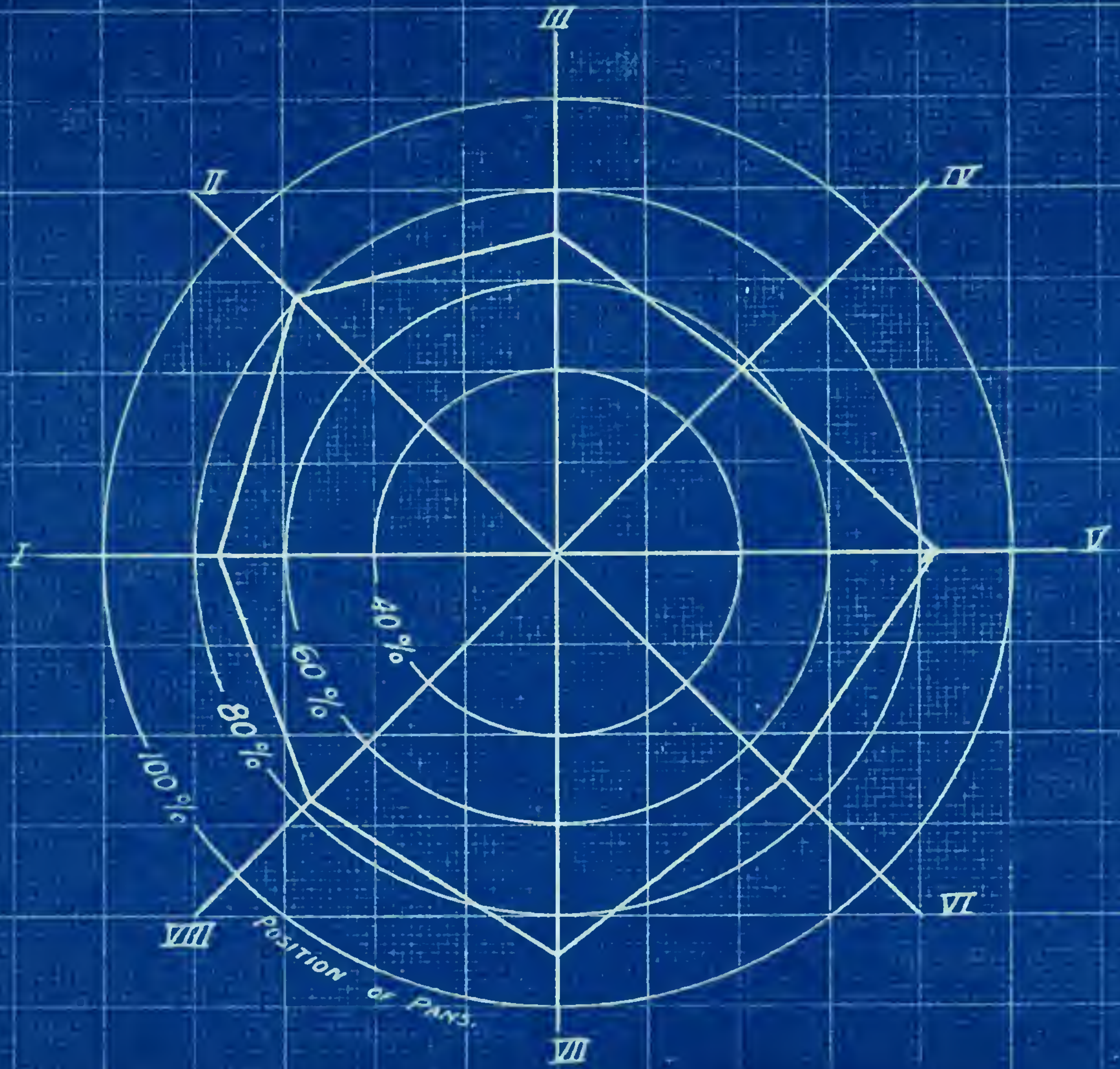
SECTOR DISTRIBUTION CURVE.

DEFLECTOR 10" DOWN
EFFECTIVE PRESSURE -6.97 #/in²
MAY 1915.
W.H.R. T.K.P.

SET #4

SECTOR DISTRIBUTION CURVE.

DEFLECTOR 3" DOWN.
EFFECTIVE PRESSURE - 30.53 #/in²
MAY 1915.
T.K.P. W.H.R.

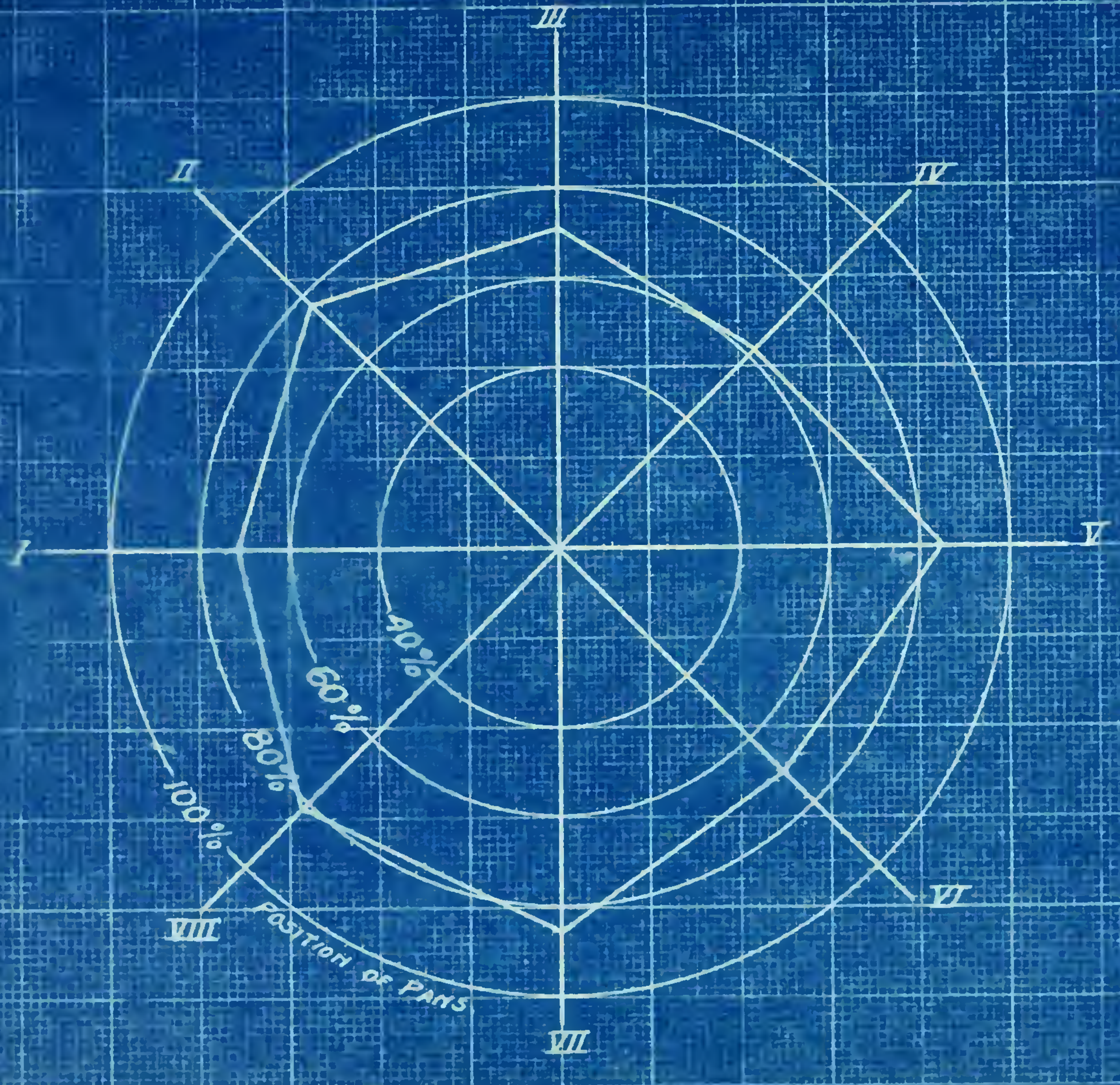


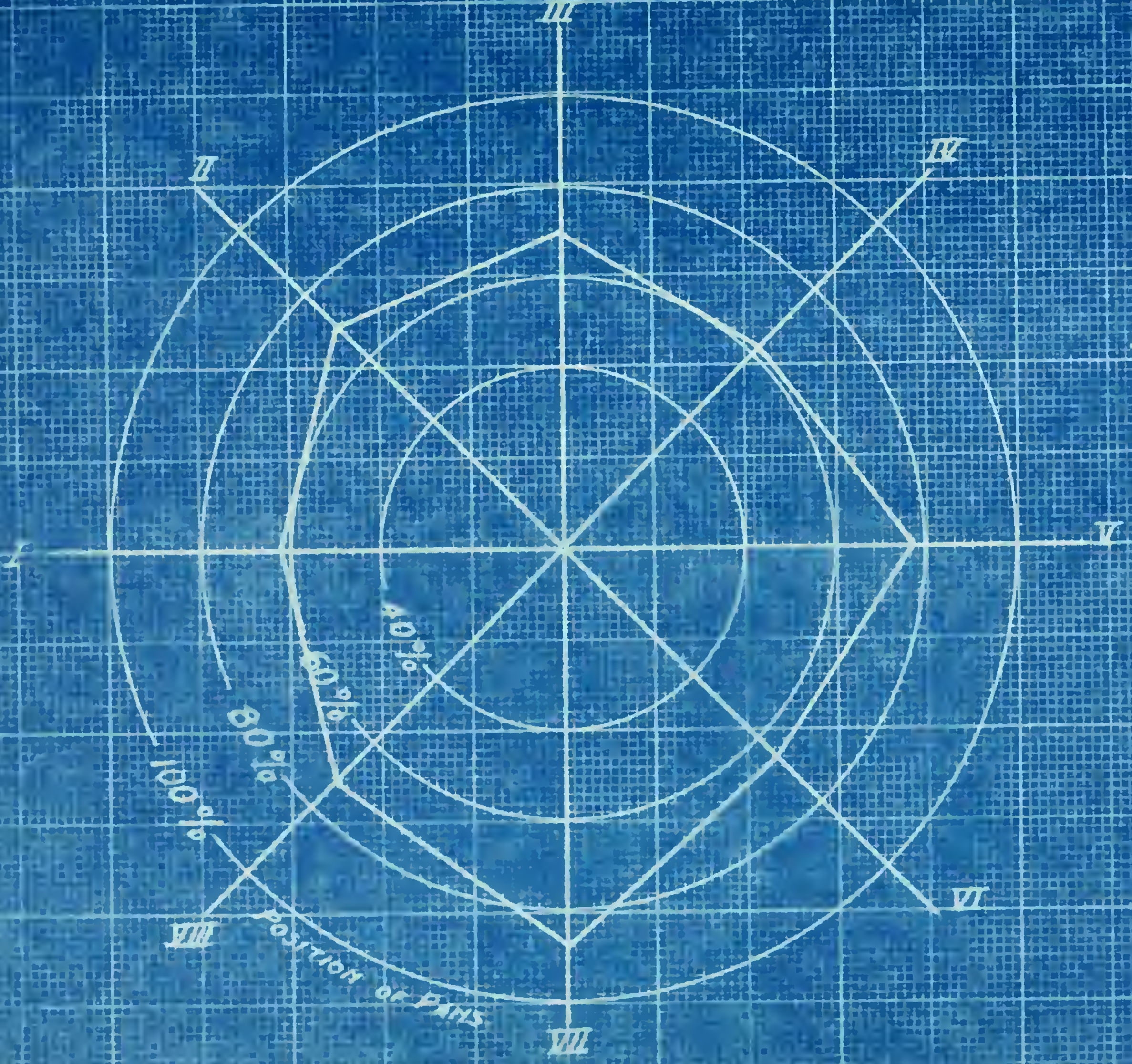
7

SET #5.

SECTOR DISTRIBUTION CURVE.

DEFLECTOR 6" DOWN
PRESSURE (EFFECTIVE)-30.64#/IN.²
MAY 1915
T.K.P. W.H.R.

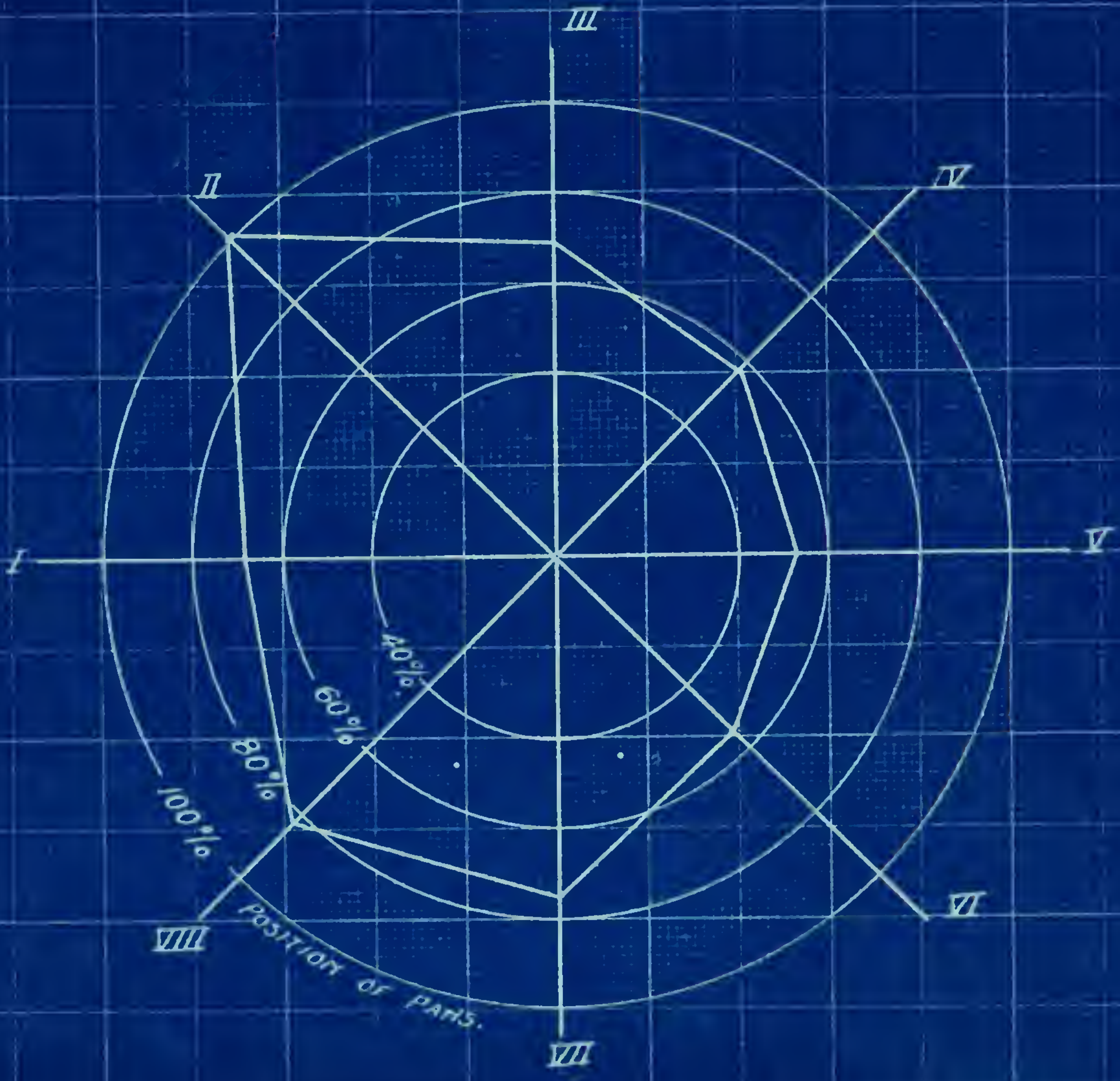




SET #6.

SECTOR DISTRIBUTION CURVE.

DEFLECTOR 10" DOWN.
EFFECTIVE PRESSURE-30.75 #/in.²
MAY 1915.
T.K.P. W.H.R.



SET #1

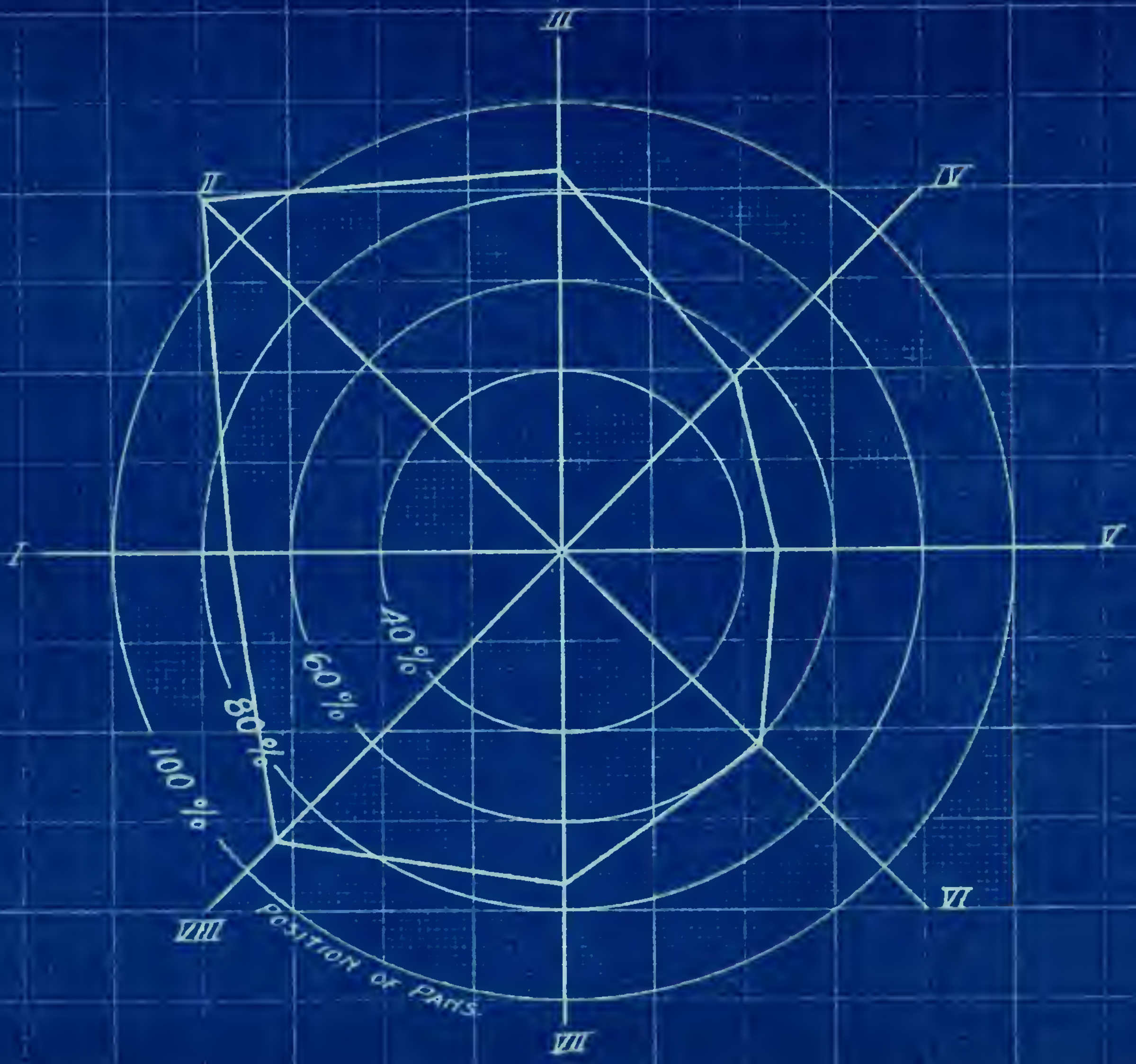
SECTOR DISTRIBUTION CURVE.

DEFLECTOR 3" DOWN.
EFFECTIVE PRESSURE - 91.6 #/in.²
MAY 1915.
T.K.P. W.H.R

SET #8.

SECTOR DISTRIBUTION CURVE.

DEFLECTOR 6" DOWN.
EFFECTIVE PRESSURE - 91.6 #/in²
MAY 1915
T.K.P. W.H.R.



SET #9.

SECTOR DISTRIBUTION CURVE.

DEFLECTOR 10" DOWN.
EFFECTIVE PRESSURE - 91.6 #/IN.²
MAY 1915.
W.H.R. T.K.P.